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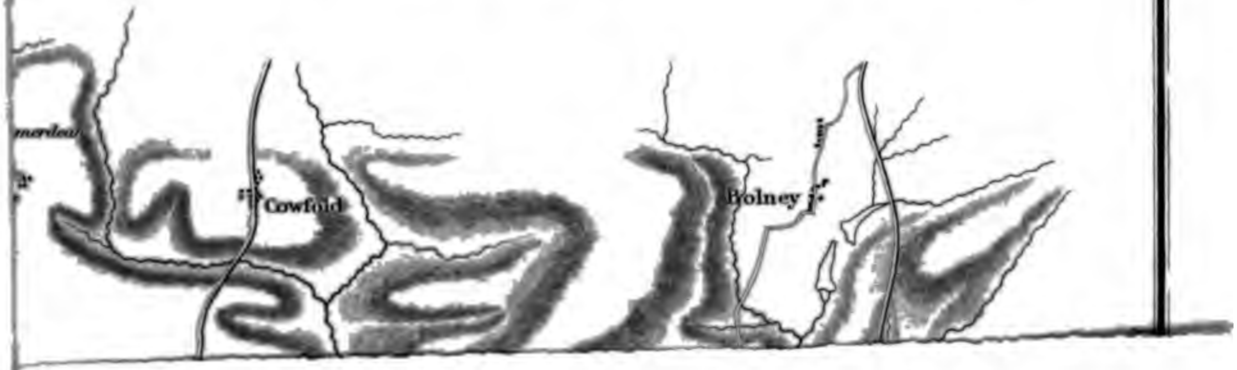
| Formations. | Subdivisions & subordinate strata. | | |
|---|---|---|---|
| Chalk | | | ☐ |
| Glauconite | Malm | | ☐ |
| | Galt | | ☐ |
| | Shanklin Sands | Ferruginous sand | ☐ |
| | | Lower Green sand | ☐ |
| Wealden | Weald Clay | | ☐ |
| | Wealden Sand | | ☐ |
| | Sussex-Marble | | ▨ |



A

# GEOLOGICAL MEMOIR

ON A PART OF

# WESTERN SUSSEX;

WITH SOME OBSERVATIONS UPON

## CHALK-BASINS, THE WEALD-DENUDATION,

AND

## OUTLIERS-BY-PROTRUSION.

BY

P. I. MARTIN.

> Ipse tridente suo terram percussit: at illa
> Intremuit, motuque sinus patefecit aquarum.
>
> OVID. METAM.

LONDON:
SOLD BY JOHN BOOTH, DUKE STREET, PORTLAND PLACE.

1828.

HOWLETT AND BRIMMER, PRINTERS,
10, FRITH STREET, SOHO.

TO

# THE REV. JOHN AUSTIN.

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DEAR SIR,

YOU did me the honour to think that there was some originality in my speculations upon the geology of the Weald district,—and this Essay was begun at your suggestion.

If it contains any thing worthy of observation, it is mainly owing to your prompt assistance; for which I am very much your debtor; as well as for the renewal of the pleasures of a study long laid aside.

You know also how much I owe to the urbanity of Dr. FITTON, the President of the Geological Society, for corrections and references, which his intimate knowledge of the subject so well entitles him to suggest. But in acknowledging Dr. FITTON's assistance, it is with no wish that he should be made answerable for my inaccuracies, or for any of the opinions, practical or theoretical, in which I indulge.

I am,

Dear Sir,

Your obliged and faithful Servant,

P. I. MARTIN.

PULBOROUGH, *January* 1, 1828.

# ADVERTISEMENT

TO THE

# GENERAL READER.

The professed geologist,—the hard-working-man, with his hammer and chisel, his maps and synoptical tables, who affects a perfect abhorrence of every thing theoretical, may turn at once to the "District Survey:" for this he will find the only part of the following Essay likely to gratify his taste for the matter-of-fact details, which he is right perhaps in believing will lead him, or some of his descendants, to just conclusions in his favourite science.

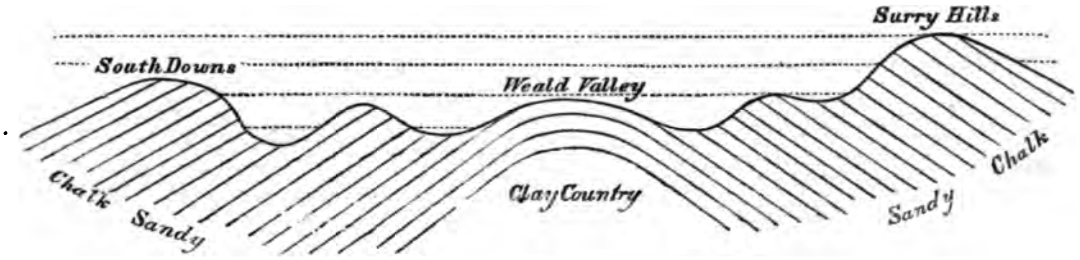
Leaving him in his work-shop, heaping up riches for others to enjoy, a few words may be addressed to the less eager inquirer; who, for amusement, or with the love of novelty, or the no less laudable motive of wishing not to be found entirely ignorant of a subject beginning to be popular, as already it is fashionable, is led to the perusal of these few pages, in the hope of adding something to his stock of pleasure, or of profit. For although "all the fine folk now-a-days, run up and down amongst the hills, knapping stones to find out how the warld was made," yet the subject may not be so familiar to the numerous class glanced at by the satirist, as to render it superfluous to give a slight general sketch of the ground of research, and the topography of the district, of which the geognosy is professed to be disclosed.

The general reader, who is not versed in geological pursuits, is therefore informed, that the part of Sussex here attempted to be described, is a small portion of the wide valley of the weald of Sussex, Kent, and Surry, which, commencing under the chalk-hills of Alton, in Hampshire, terminates in the sea-coast, which extends from Dover to Beachy-Head; bounded also on each side by the chalk of the North and South Downs.

It must be well known to every traveller who has crossed this valley; that upon descending from the chalk-hills in any part of its western extremity, he enters upon a tract of sandy country, occasionally rising into considerable eminences, and of very varied agricultural aspect. From thence he descends still farther into extensive, woody, and cultivated districts of clay soil, and of exceedingly undulating surface. Traversing this clay country, locally called, and by notoriety, the proper "weald," he emerges again across the same sand, to reach a range of chalk-hills, similar to those he left behind him. In the eastern part of the valley, the same series is observed, with the difference, that the sands immediately below the chalk are not so prominent, and the middle of the clay country has a greater intermixture of sandy lands, not destitute of picturesque beauty, but of inferior agricultural character.

The space thus comprised, has otherwise, in geological language, got the name of the "Weald Denudation;" because there is every reason to believe, from the uniformity of the structure of the valley, and the regularity and peculiar disposition of its chalk boundaries, that the chalk itself, and all its subordinate strata, with perhaps some others often found incumbent upon the chalk, have been once continued over it from side to side, (all uniting to form a high table land, but a small part of a greater expansion of the same materials,) and of which it has since been stripped or denuded.

## PROFILE OF THE WEALD DENUDATION.



To explain better what is understood by this denudation, or stripping off of the chalk strata,—let the reader imagine a plain of chalk, covered or not with other lands of a kindred nature, extended over a part of France, and continued without interruption to the north of England. Let him then suppose, that, looking from above the Alton-Hills, he sees the chalk, with its accompanying strata, rent asunder; part sinking southward to give a bed to the English-Channel, from the race of Portland to Beachy-Head, (leaving some fractured portions standing, to tell the story of convulsion,) part northward, to form the south side of what is called the London basin, from Marlborough Downs to the Straits of Dover.

Let him also suppose, that whilst this is in progress, and all the immense intervening masses are fissured and crumbled by convulsion, a flood of water, powerful beyond comprehension, at the same instant, or immediately after, rushing over, and entering the broken surface, sweeps the whole contents of what is now the weald excavation before it, into the North Sea—itself but a part of the abyss just then opened, perhaps by the same concussion, to receive them.

Or, let

> " A change come o'er the spirit of his dream:
> " That is not all a dream."

Let him suppose this part of our island lifted up out of the bosom of the ocean by an impelling power from below, some parts of it more steadily and evenly, others with such irregular and successive heavings, as to produce the effects above spoken of; disruption of the central parts, and such fissuring and rending of the circumference, as an irregular action is calculated to produce upon a ponderous and frangible material.

Such a dream, splendid as it may be, will fall far short of the reality of those changes that can be demonstrated to have taken place in parts of the world, well understood to be more ancient than these under consideration.

If the mind is staggered at the immensity of such an operation, let it be answered—that the weald valley is but a small furrow on the earth's surface. And let our thoughts revert for comparison to many greater natural phenomena;—to the height of the Himalaya, which may be well supposed to have felt the power of the same ocean stream, perhaps to have been lifted out of it—or to the five miles of depth, which may be given to that ocean,—and then consider how small a proportion the aggregate ten miles holds to the diameter of the globe itself.

Nothing is great, nor nothing little in the operations of nature; and such disclosures as these sink into insignificance before the wonders of Astronomy! The mind is lost in the contemplation of the immeasurable POWER to which it is indifferent, that

> "Now a bubble bursts, and now a world."

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The author would beg pardon for the triteness, or the unfitness of these observations, but it will soon be seen, that a geologist is any thing but poetical.

The county of Sussex, as part of the scene of these convulsions, possesses great geological interest. Its organic remains have employed the pens of able illustrators, and drawn much public attention; but a harvest of interesting facts and observations yet remains for the reaper; particularly in what relates to the great geological features of the county—its hills, vallies, and water-courses, and the disposition and relative bearings of its parts. No apology is necessary for local details that tend to illustrate any general proposition—and nothing can be too minute that is relevant.

"Men use commonly to take a prospect of nature, as from a high turret; and to view her afar off; and are too much taken up with generalities. Whereas, if they would resolve to descend and approach nearer to particulars, and more exactly and considerately look into things themselves, there might be made a more true and profitable discovery and comprehension."*

To do justice to such a subject as a Geological History of Sussex, or of the Weald Valley, would require months of travel, a minute inspection into every part of the country, and months of study and reflection. A geologist must not take any thing upon report; he must see with his own eyes, and carry into all parts of his subject a unity of observation. The man who would do this for a complete history of the Weald Denudation, and of the accompanying chalk-basins, as they are called; explaining their relations to each other, to their contents, to the surrounding countries, and the western denudations, would do more for the advancement of the science, to simplify its study, and correct its errors, than at first sight appears, or than it would be safe at present to predicate.

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* Lord BACON.

## CORRIGENDA.

**Page 4, 13th line from top,** ***for*** **" Whitby,"** ***read*** **" Pickering."**

**Page 40, 10th line from top,** ***for*** **" adjacent,"** ***read*** **" subjacent."**

**Page 50, 1st line,** ***for*** **" The diluviæ of the ferruginous sands are,"** ***read*** **" The diluvium of the ferruginous sands is"**

**Page 72, 8th line from top,** ***for*** **" rivers receive,"** ***read*** **" river receives."**

**Page 87, bottom line,** ***for*** **" poudinques,"** ***read*** **" poudingues."**

# INTRODUCTORY REMARKS.

THE substance of the following Memoir was read before the Geological Society in March last, and attracted some attention to the speculations it contained on the joint operations of fissure and denudation; and from its bringing again into discussion the arrangement and nomenclature of the beds immediately below the chalk;—the latter subject, notwithstanding the illustrations of many able geologists, being still considered as not finally settled.

The researches of Dr. Fitton, and Mr. Lyell, in the south-east of England; of Mr. Murchison, in Western Sussex; of Professor Sedgwick, on the Yorkshire coast; and Mr. De la Beche, in the vicinity of Lyme-Regis; seem to have effected all that could be desired, except a general agreement as to the propriety of certain groupings, and subdivisions, and as to nomenclature.

It would be foreign to the purpose of this Essay, to go over all the grounds of debate, or to decide affairs left in abeyance by such able inquirers. But it will be necessary to premise some observations upon the views which have led to the choice of an arrangement, and a nomenclature, best suited to the purpose of a survey of this district. The importance of the imposition of names, is shown by the disagreement amongst the naturalists who have written upon this subject; which seems to have arisen from the misapplication of two or three words, geologically of very indefinite meaning,—first, of *Iron and ferruginous*, and afterwards of *Upper* and *Lower Green;* and this discrepancy has been continued by attempts to observe a uniformity which nature does not acknowledge, and to preserve divisions which, although they may be useful for the purposes of geological topography, are only of very limited application.

Amongst the causes of this disagreement, also, it must not be overlooked, that the attempts which have been made to establish a contradistinction of strata, or of the different members of formations, by the peculiarities of their organic fossils, have not been so successful, or so satisfactory, as not to admit of much dispute.*

There is little danger now of a repetition of the mistakes respecting the ferruginous or upper beds of what is called the Shanklin-sands, and the true iron or Hastings-sand. The same may be said of the galt and the weald clay. But as the interposition of the galt has kept up the distinction of upper and lower green-sand—a distinction not always observed, and constantly leading to confusion, it would certainly be desirable to get rid of it, and reunite them, if it could be done without too much violence to established usage, and a natural classification.

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* What material difference, for instance, is to be found in the fossils of the galt, and of the green-sand above it and below it? The zoological characters which serve to distinguish the æras of formation upon the large scale, fail when they come to be so nicely applied as to serve for the subdivisions of strata. An inquirer meets with an abundant fossil in a particular stratum, and exclaims, Here is the fossil of this formation; another naturalist goes to work in another locality, and discovers a similar shell, or a similar bone, and all again is confusion. Then follows the modern abuse of the word formation.

The upper green-sand belongs properly to the chalk, where the French naturalists have placed it, under the name of craie chloritée, or glauconie crayeuse,* and it has so much of the argillaceous character, and glides so insensibly into the galt, that it might with propriety carry the latter along with it. The true green-sand might then have begun with the upper member of the Shanklin,† between which and the galt there is a strongly marked and much better line of demarcation.

But as the English geologists have placed the green-sand immediately below the chalk, and long usage has established it there, it is too late to make such an entire change; nor does it seem necessary for a simple and natural enough arrangement. For if it be proved that galt may take the place of the upper green-sand, or malm, and that clay, like galt, pervades the lower green-sand; that there exists no great dissimilarity in their fossils; and that the fossils of the lower green-sand assimilate so much to those of the upper, that the characteristic ones are the same; there can, upon the principle of geological equivalents and contemporiety of formation, be no impropriety in grouping these strata under one head.

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* Some writers seem to consider that the malm, or upper green-sand, is the tufau of the French: the description of which, " grisâtre et sableuse," answers well enough to our grey-chalk; whilst in mineralogical character and geological position, the glauconie crayeuse exactly tallies with the malm, or upper green-sand; " qui est grisâtre, friable, et toute parsemée de grains verts, qui ont la plus grande resemblance avec la chlorite, et de nodules verdâtres ou rougeâtres qui d'après l'analyse qu'en a faite dernièrement M. Berthier, renferment beaucoup de fer et souvent tant de chaux phosphatée, qu'ils en sont presqu' entièrement composés."—*Brongniart Des. Geol. des Environs de Paris, p.* 13.

The Parisian geologists do not seem to be very intimately acquainted with the beds below the chalk, and it is probable that the *tufau* and *glauconie crayeuse* are the same, or analogues of each other. The " *silex cornés*" of the former, answers to the chert of some of our malm; and the description of the latter will do for the malm, where it graduates without chert, from the chalk into the galt beneath—being sometimes arenaceous, and sometimes argillaceous and nodular, or concretional. All this is of very little consequence, but to show how variable this deposit is, and explains the discrepancies that have arisen from that variety.

† This has been done by Humboldt, who places the sable-vert directly under the craie-chloritée.

Notwithstanding what has been said by Professor Sedgwick,* it may be suspected still, that the "upper shale" of the "Survey of the Yorkshire Coast," is galt. The galt as it appears in some parts of Sussex and Surry, is immediately recognised as the Whitby shale, and its situation in the place of the green-sand identifies them.† The absence, again, of the galt in the west of England, and the substitution of a suite of green-sand strata, as described by Mr. De la Beche; the gradation of the malm into the galt, in the west, and the position of the green-sand immediately under the chalk, without the interposition of malm, in the east of Sussex; ‡ all bespeak a community of character—a community still further maintained by a comparison of their fossil zoological relations.

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* Annals of Philosophy, 1826.

† As to geological position. It is more likely that the Kimmeridge clay should be wanting, along with the Purbeck and Portland beds, and the Wealden, than that the whole of the marine deposit of the glauconite should fail.

‡ At Southbourne.—If the bed of *green-sand* immediately below the chalk at Southbourne has what has been called " blue chalk-marl" above it and below it, the arrangement is the same

Agreeably to these views, therefore, and to the observations of Messrs. Sedgwick and De la Beche upon this subject, it is proposed to unite the whole suite of sands and clays under the appellation of *glauconite ;* retaining some of the old names in a subdivision, for the convenience of local description. This word is preferable to the old name of green-sand, because it is agreeable to the analogies of geological nomenclature, and because it involves no other than a general mineralogical meaning, and gets rid of the confusion about *upper and lower*, whenever green-sand is mentioned.

Another uncertainty as to nomenclature, arising out of the use of the words upper and lower, still seems also to affect the upper member of the glauconitic series. Whilst some contend for the retention of the original name of green-sand, attempts have been made to substitute others, unobjectionable perhaps in themselves, and not wanting authority to consecrate their use.

Dr. Fitton, the accurate explorator of these formations, has made use of the word firestone, but has since abandoned it, and seems disposed to adopt that of upper green-sand.* Mr. Murchison, who has used the nomenclature of Dr. Fitton, and made out the best suite of fossils for this stratum, makes more use of the word malm-rock, than of the adopted name of firestone ; and in all the great development of it reviewed by him in Hampshire and Sussex, the malm rock, provincially so called,

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as in all this line of country, where it occurs in beds like an interrupted stratum, always in the upper part of the malm. The malm, both above and below the green-sand, except the most indurated, whitens by exposure to air ; and it is probable that the overlying malm, or marl, of the Southbourne green-sand, may, on that account, be mistaken for chalk.

* Proceedings of Geol. Soc. 1826-7.

greatly predominates over the green-sand and hard slate-coloured marl, its subordinate members.

In this unsettled state of things, and being at liberty to choose, the word "*malm*" has been preferred, to designate every thing interposed between the chalk and the galt. First, because the word itself, like galt, lias, killas, &c. has no meaning or applicability beyond the thing signified. For, although it is partially and provincially applied to soils geologically different, it is not very extensively so. It is most probably a corruption of marly, marlen, or marlem land; and it would be difficult to find any word, not absolutely coined for the purpose, not liable to some objection. In Surry, it is used indifferently for the galt land, or for that formed by the debris of the rock in question; and the common people are inclined every where to call a slaty, argillaceous substance, which runs by frost, blue marl, or marly ground. And, secondly, because it has acquired a classical character in its use by White, the naturalist of Selborne. His description of the "white and black malm," graduating into the galt clay, and succeeded by the sand of Woolmar Forest, in his second letter, will stand for any part of the foot of the Surry, Sussex, and Hampshire Downs.

Any stone of a particular combination of lime, argil, and silex, may be a firestone: and the reasonable objection to green-sand is, that it has been productive of much confusion, and is to be found above the chalk, and below the weald clay.

With the nomenclature of the suite of strata next below the glauconite, some liberty has also been taken. It is hoped that proof is here given* of the identity of what have been hitherto considered, or at least treated, as two distinct formations; an attempt has been made, therefore, to give them a collective designation.

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* See "District Survey;" the courses of Hastings-sand high in the weald clay, and above he Sussex marble.

Whatever may be supposed to have been the nature of the agency of these deposits, there can be no doubt of their common character and single origin. There is, in fact, no weald clay distinct from the iron or Hastings-sand; and if it be true, as is now generally believed, that they are both local, or what are called fresh-water formations, they must necessarily be one and the same throughout, there being no intervening formation of another order.

Of the extent of this locality, and of the area assigned to their kindred deposits, it would not be safe to speak decidedly at present. The discovery of cyclades and cypris faba in the Purbeck beds, and of the position of these and the Portland beds in the Boulonnois,* where the weald-clay and Hastings-sand are wanting, with the general affinity of some of the former to the Petworth marble, render it extremely probable, that the equivalents of the weald formations will be found out of the area which has hitherto been strictly assigned to them.†

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* Proceedings of Geol. Soc. for 1826-7, pp. 27—29.

† The wealden has not been detected in the north of England, nor, what may prove to be its equivalent, the Purbeck beds; and the confusion respecting the ferruginous, or upper part of the Shanklin, and the iron or Hastings-sands (a part of the wealden), renders it doubtful how far they have been traced into the interior. A stricter examination of the beds below the chalk, upon the opposite side of the channel, west of the Seine, must also be made before we define the area of this formation.

That the discovery which has led to these observations, and the arrangement here proposed,—of courses of sand with limestone and fossils, resembling those of Hastings,* high up in the weald-clay, was not made earlier, may be accounted for, from the circumstance of their being lost upon the coast under Romney and Pevensy marshes, and from the complete bevilling off they have suffered by diluvian erosion, as they approach the coast. The coast sections which have been taken for a text for subsequent researches, have been too much relied upon for this part of the Island, and have helped to lead to some of the confusion about green-sand and iron-sand, above descanted on.

In the Isle of Wight, and upon other parts of the southern coast, the proper weald-clay holds a very small proportion to the remainder of the series, and that may perhaps be yet curtailed by a closer inspection. That a valley of erosion almost always exists where this clay is exposed, is not sufficient reason for keeping it distinct from its kindred parts.† If such natural features, like agricultural character, were to be made the guide, division and subdivision would be endless.

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* The word "Hastings" is used, because the sand has all the natural characters, mineralogical and zoological, of that sand.

† The two uppermost courses of Wealden sand carry very little stone, and thence have been as little able to resist the denuding stream as the clay in which they are enclosed, and they combine, therefore, in the valley of erosion which that stratum generally presents. If the existence of a valley of erosion between the two groups of which the Shanklin sands of this district, and of eastern Kent, consist, be not considered a natural feature sufficient to warrant their division into separate and distinct formations, why should not the same rule apply to strata of greater community of character?

In the choice of a name, the writer has been guided by a wish to do as little violence as possible to inveterate habit, as well as to adhere to the useful practice of deriving it from the locality in which the type is best exemplified.

In travelling over the weald, strictly so called,* (the country interposed between the escarpments of the glauconite,) no person would hesitate in calling it a clay district; and its sands are sufficiently argillaceous to merit the association. Hastings-sand, therefore, or Iron-sand, would be as little designative of the whole thing signified as Weald-clay. And to avoid the inconvenience of the periphrasis of weald sands and clays, it is proposed, as any compound from weald must have a Saxon termination, to call the whole formation the *Wealden*.

The word weald is gone into foreign countries, associated with these formations; and the compound will be immediately recognised, as well as glauconite. Some convenience will also be felt in a designation which implies neither sand nor clay, when other local deposits of the same age and nature come to be discovered and described, as doubtless there will be.

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* Provincially, the clay country only is called "the weald;" and the inhabitants of the Shanklin-sands, fertile or infertile, woody or bare, scarcely confess themselves denizens of the weald, although they are below the chalk. Strictly speaking, perhaps, they are right, although geologically and geographically, it is convenient to consider all the valley, weald, from chalk to chalk. The boundary of the *Sylva anderida*, was the escarpment of the lower green-sand, and there is good reason to believe that the Romans found all the tract of country between it and the chalk-hills, as they left it, well peopled and cultivated; whilst the clay country remained the impracticable forest, to which the Saxons came to give another and more lasting name.

Much indulgence must be craved for a first attempt to describe the disposition of the several parts of the country under review, and of the phenomena of displacement and derangement, and out of them to deduce some conclusions illustrative of a theory of the *weald denudation*. The writer's residence in a neighbourhood favourable to observation upon the stony strata, has enabled him to collect much presumptive evidence of the "modus operandi" of that catastrophe. That more direct proof of a part of that operation, of convulsion and fissure anterior to, or coeval with, watery erosion, does not exist, is not wonderful. The difficulty of separating the signs of these compound actions, and of assigning to each its proper share, will be sufficiently apparent. The removal of the fractured portions of the friable strata, the obliteration of the lacerations of the more tenacious, and their obscuration by their own rubbish; and, superadded to these, the chemical operations of time, and the dilapidations of ages; render it only wonderful that traces are yet to be found that lead to these conclusions; and it is only by their review in the aggregate, that any satisfactory result is to be obtained.

When the research was made which led to the composition of this memoir, and up to the time of its being presented to the Geological Society, the writer was entirely unacquainted with the existence of any attempt to explain the act of denudation by any other agency than that of watery flood. His own speculations upon the appearances of the country, the disposition of its vallies, the dip and lateral bearings of its strata, and the courses of the rivers through them, had produced a conviction of some other agency besides that of water having been called into action, and that that agency had at the same moment of convulsion formed what are called the chalk-basins of London and Hampshire, and in that act broke up what is now the cavity of the weald.

If by subsequent information, and an extension of his reading, he has been deprived of the satisfaction of believing himself the first to promulgate this discovery, he has the pleasure of finding his opinions backed by high authority; and is emboldened to carry on the research to a satisfactory exposition of many of the facts which bear upon this theory, and are strong presumption, if they do not amount to a perfect proof, of its truth.

In a work upon Volcanoes, published by Mr. Powlett Scrope, in 1825, a sketch of this theory of the weald was promulgated; and about the same time, Professor Buckland, in a memoir read before the Geological Society, in February, 1825, and published in 1826, gives a conjectural explanation of the same kind.

Mr. Scrope's exposition forms a part of an extended speculation upon volcanic operation generally, which it is unnecessary to explain in this place. He calls such vallies, "vallies of elevation," or "anticlinal vallies." The Valley of the Weald is thus alluded to:— "Where such anticlinal vallies are on a large scale, as the instance of the weald of Kent, transverse fractures appear to have been also formed in the subsiding strata; but these will have remained, more or less, narrow crevice-like gorges; since no subsidence can take place away from them, that is in a direction coincident with the axis of elevation. These transverse chinks, or gaps, are frequently the channels through which the drainage of the interior valley has been since effected, while they have been enlarged, and have lost the angular roughness of their fracture edges, by denudation or meteoric abrasion. Such are the gaps in the chalk escarpment of the Kent and Sussex valley, through which flow the Wey, Mole, and Medway, towards the north, and the Arun, Adur, Ouse, and Cuckmere, towards the south." *

Dr. Buckland, apparently by accidental consent, has also called such vallies, having a central nucleus from which the lateral parts decline, "vallies of elevation." A review of the phenomena of such elevations, and consequent depressions, has also led him to question the deposit of tertiary strata in the hollow spaces of the chalk. Whatever may be the fate of Mr. Scrope's general hypothesis, so much of it as is here contained can certainly be borne out by a train of incontrovertible facts,

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* Scrope on Volcanoes, p. 213.

although the "modus operandi," and correlative chain of actions with which he connects it, will admit of much dispute. A greater share in the operation has been ascribed to the sloping off, or the sliding of the parts upon each other, than is justly due, and less to the simple action of stretching or bursting up.* In the concluding observations of this Essay, will be found some attempt to combine the operations of basining and denudation, and the inferences deducible therefrom.

If in some of the foregoing observations, as well as in what is to succeed, the writer has been constrained to use language bordering upon the controversial, it must be remembered, that such a tone appears to be assumed, in every statement of a difference of opinion; and if he is compelled by circumstances to make use of a different arrangement, and a nomenclature differing in part from that which has been lately used, it is necessary that reasons should be given for such deviations. The object is to simplify, rather than to innovate. The glauconite is the green-sand formation of the earlier writers, and the wealden is a local and peculiar, or else a part of a widely-interrupted formation.

If the depression of the chalk and its underlying strata, and the formation of denuded vacuities, were coeval and consentaneous acts, there have been no "deposits made in chalk-basins." The solution of this proposition is of material consequence to geology; and it is hoped that in opening upon it, the subject has been treated as practically as possible. It would have been easy to run into the hypothetical and conjectural; but the writer has confined himself to such speculations as could be legitimately deduced from the facts that have come under his personal observation, or such others as are too well known to be disputed.

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* The angle of elevation, or subsidence, is too trifling to dispose the parts to slide away, supposing that that action were possible. But the slightest movement out of the horizontal posture would be sufficient to break the surface, and give admission to the denuding flood.

# DISTRICT SURVEY.

The district made the object of this geological research is comprised in that part of Sussex which extends from the Adur, between Steyning and West Grinstead, on the east; and the little stream (which for convenience may be called the Lod) which runs into the Rother by Lodsworth and Half-way-bridge, between the chalk downs at Graffham and the foot of Blackdown, on the west.

The Map which is annexed (extracted from the Ordnance Survey) is also coloured on eastward as far as the Brighton road, by Hixtead, for the purpose of including the whole of the weald clay valley contained in the Shanklin sands, produced by the disruption of Jacquets-Hill, and Henfield; and which is here called the Vale of Greenhurst.

According to the plan proposed in the introductory remarks, it is intended to consider first, the structure of the component parts, and the order in which they present themselves, beginning with the higher, or, geologically speaking, the newer formations, and proceeding downwards. This happens also to be the geographical arrangement; because, as

Blackdown is not intended to be included, there is no eminence in this part of the country which overtops the chalk hills.

The order of superposition, or rather of subterposition, of the strata, and the division and subdivisions intended to be made, are,—

1. ALLUVIUM.
2. DILUVIUM.
3. CHALK.
   1. Upper, or with Flints.
   2. Lower, or without Flints.
4. GLAUCONITE.
   1. Malm.
      *Upper Green-Sand.*
      *Malm Rock.*
   2. Galt.
   3. Shanklin Sands.
      *Ferruginous Sand.*
      *Lower Green-Sand.*
5. WEALDEN.
   1. Weald Clay.
   2. Wealden Sand.

The two that come first in the list, are, where present, the first upon the surface; but it will be most convenient to consider them afterwards, because they are made up in great part of the materials of the regular strata.

## CHALK.

This formation has been so often described by geological writers, and its fossils have been so ably illustrated by Mr. Mantell, that it would be superfluous to dwell upon it here. In its course east and west, it forms the natural boundary of the district here surveyed, as it does, in whatever direction it may extend, of the whole of the weald valley; and has beneath it all the other strata, as they are successively exhibited, to the bottom of the weald.

The upper beds, or those which contain flints, form the crest of the chalk escarpment from Steyning to Duncton Hill. They are extensively quarried at Houghton, as is also the lower and harder chalk at the foot of Houghton bridge. Between these pits, and intersected by the river Arun, is a small outlier of the sand of the plastic clay formation, which will be spoken of by-and-bye, in treating of the order of displacement and denudation.

The lowest beds of chalk furnish the variety called " grey-chalk," which reposes upon the green-sand, and seems to derive its greenish-grey colour from the contiguity of that mineral. This appears to be the nearest allied to the tufau of the French geologists.*

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* *Minerals of the Chalk:—*

Pyrites.

*Organic Remains:—*

Wood, rarely.

Supposed Juli of Larch (since conjectured to be marine).

Ventriculites.

## MALM.

*Firestone and Merstham beds of Dr. Fitton; Upper Green-sand of Professor Sedgwick, and other authors.*

Agreeably to the arrangement and nomenclature proposed in the introductory observations, it is intended to include under this head, all the formation interposed between the chalk and the galt, with the subdivision into upper green-sand and malm rock.

Choanites.
Apiocrinites.
Conulus.
Cirri (three species).
Ammonites (five species).
Belemnites.
Plagiostoma.
Ostrea.
Terebratulæ (three species).
Inocerami (four species).
Astacus.
Squali (teeth of three species).
Balistes (fins, or radii).
Diodon (molar teeth of).
Zeus.
Murena.
Salmo.
Amia?

*Mantell's Geology of Sussex.*

The most remarkable inorganic fossils are, flint nodules, and crystals of carbonate of lime.

The transition from the pure chalk to the malm, is through an intermediate chalk-marl, varying in thickness and consistency. In this district, its out-crop is very obscure, and does not form a country distinct from the other chalky beds, nor is it quarried for domestic purposes; but when accidentally opened, it is found to abound in a great variety of marine fossils.

This marl passes into the malm, of which there is a thin stratum, succeeded by a bed of green-sand, and that by the more indurated malm rock, which again gradually resolves itself into the galt clay beneath.

The green-sand, which gave the original name to this formation, is sometimes disseminated through the whole mass; at others, it exists in distinct beds, which crop out, deprived of their upper coat of malm rock, and form an arable land, somewhat more porous than the malm in general, but, being mixed with diluvial earth, and the detritus of the chalk, is scarcely distinguishable from the other malm land, and not inferior to it in fertility.

The best sections of this stratum are to be found at Steyning, Amberly, Bury, and Barlavington. Its relative position is very well exposed in the hollow way leading to the downs at the latter place, and better in the hollow leading from the turnpike-road to the church, at Bury. It is here from fifteen to twenty feet in thickness.

These beds of green-sand are never found but in the upper part of the malm formation.

The great body of malm rock next succeeds, advancing in a bold and broad talus, at the foot of the chalk hills.* And it is worthy of remark, that it is broadest on the eastern side of every remarkably salient angle of the chalk. Accordingly, the broadest exposure in this part of the country, is between Sutton and Bury, under shelter of the projecting hills of Duncton and Sutton.† The wells are from 30 to 100 feet deep, and the average depth of the whole stratum may be about 70 or 80 feet.‡

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* Nobody, who has examined the great development of the malm, or upper green-sand, of this district, will doubt of the manifest propriety of associating it with the chalk formation. Except the green arenaceous beds, above spoken of, it is uniformly an argillaceous limestone;—soft, and therefore receding above, where it graduates into the chalk—indurated in the middle, and therefore protruding and forming a plateau—soft again at bottom, and melting into the galt clay, (where it seems that it sometimes does, and sometimes does not lose all its cretaceous character,) and uniting with it in a valley of erosion.

† The indurated malm, in the form of what is called malm rock, is not confined to the country west of the Adur. Its terraces are well characterised eastward, by Edburton and Poynings; and the hollow ways at these places, and at Fulking, exhibit very good sections of it. In this district, it is never perfect chert, and it rarely exists as an arenaceous stone.

By these observations, the author does not mean to infer, that this formation, or stratum, does not exhibit different appearances elsewhere.

‡ It is very difficult to come to any satisfactory conclusion upon the thickness of strata, which have suffered so much disturbance as all these under review. Wells cut them obliquely, and seldom in their thickest parts; and natural and artificial sections seldom exist but in their escarpments and basseting edges, where they have been beviled off by denudation. It is probable that 100 feet would be no exaggeration of the thickness of the malm, at the foot of the chalk hills, where it begins to emerge.

In its most indurated state, the malm rock has a conchoidal fracture, and is of a bluish colour when fresh broken, but becoming white by exposure to air. It is an argillaceous limestone, and its detritus forms a stiff loam, remarkable for its fertility. It is particularly favourable to the growth of the apple and walnut, which find rooting upon its barest rocks.

The indurated blue malm furnishes few or none of its characteristic fossils; they must be sought for in the softer and upper beds.*

It is not known as a firestone in this part of the country.

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* Ammonites, varians.  
——— Rostratus.  
Pecten Orbicularis.  
Gryphœa Vesiculosa.  
Avicula—new species.  
Echino-Spatagus (new species, figured by Konig, Icon. Sect. Foss. Cent. 2.)  
Arca Carinata.  
Pecten Quinquecostata.  
Plicatula Inflata.  
Ostrea—new species, not yet figured.  
Orbicula?  
Nautilus—compressed specimen.  
Crustaceæ, imperfect.  
Impressions of Vertebræ, and scales of fish.  
Stems of Alcyonia. *Murchison.*

Of the above fossils, the Ammonites Rostratus, and Pecten Orbicularis, are most abundant and characteristic.

Mr. Mantell considers the Ostrea Carinata, as peculiar to this stratum. Wood with

## GALT.

*Cambridge Clay, Galt Brick Earth, Blue Chalk Marl, of various authors.*

The transition of the malm into the galt clay, can nowhere be better observed, than in the hollow way leading from Sutton to Bignor. The greatest expansion of this stratum is found below the former village,* from whence it stretches out over the greater part of Bignor Park, forms the ground called the New Woods and Bury

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Fistulanæ has been found at Willingdon. The author has found Ammonites, Nautili, and Pectines in the malm.

A block of fossil wood was discovered some years ago in the upper part of the malm, at Rackham, by the Rev. John Hanley, of Amberley; and Inocerami, by Mr. Edward Rhodes. *(See subsequent note.)*

* There is a considerable expansion of the galt below Graffham, and the fine woods of Lavington, where the usual terrace-like line of demarcation of the malm is very much beviled off, and passes imperceptibly into the galt. From the latter place, and the village of Duncton, it obtrudes into Burton Park, and beds the greater part of its beautiful lake. In several places hereabout, its union with the ferruginous sand (upper bed of the Shanklin) may be observed; and it is everywhere characterised by an intermediate layer of indurated sand, or ferruginous rock, from six to ten inches in thickness—as if a crust had formed, and a considerable time elapsed before the chemical change came, or the irruption of the galt clay.

In all this country, the point of union of the galt with the underlying sand, is never without this crust; it is sometimes a conglomerate of quartz pebbles.

Common, and rises into a considerable eminence in Timberly farm, where it is lost in the alluvium of the river Arun. It re-appears at Rackham, about a mile and a half east of that river, and is continued, from a few hundred yards to a quarter of a mile broad, under the escarpment of the malm rock, to Wiston, where it expands again, under shelter of the projecting angle of Chanctonbury-Hill, and stretches over to the Adur; forming the pasture grounds immediately north of Steyning.

The Galt consists of beds of blue, brown, and sometimes red and yellow clay, passing into a black shale, astringent, and aluminous to the taste. It does not effervesce with acids, except where it has got the addition of some cretaceous matter, from the vicinity of the chalk.

Very few fossils are to be found in the galt of this district, and no metallic substance but pyrites, and concretional masses of iron ore.*

The depth of this stratum is very uncertain. The deepest well the writer has heard of, is that at Bignor Park, which is 70 feet; but from the position of the bed there, it must cut very obliquely through it. The outlier at Pulborough is about 50 feet.†

The agricultural character of the galt is moderate fertility. Good for timber, particularly oak; and good for pasture. It is tenacious of water, and of so plastic a nature, that drains are maintained in it with great difficulty.*

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* Dr. Fitton has observed a foliated gypsum in galt.

† But this can be judged of only in parts thinned off by denuding causes.

### *Outliers of the* GALT.

Remnants of the galt stratum are to be found in various parts of the district, but more particularly in the course of the river Arun. The history of these outliers is very interesting, and will be adverted to in the theoretical part of this Essay.

There is good reason for believing, that the Arun is bedded in subsided galt, from the malm at Bury, almost to the verge of the Shanklin sands. But the first outlier that appears emerging from the alluvium of the river, is in the parish of Hardham, which is a peninsula of the Arun, chiefly composed of galt, supporting a large diluvial mass. A tunnel of the Wey and Arun Canal is here carried through the galt, and a well at the Priory farm has been sunk 50 feet in it without obtaining water.

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* *Organic remains of the galt:—*

Ammonites.
Nautili.
Belemnites.
Inocerami.
Turbinolia.
*Mantell.*

*(From the Isle of Wight, by Dr. Fitton.)*
Mya Mandibula.
Corbula Pisum?
A Pecten?
Thin Shelled Ammonite.
Scales and bones of a fish.

Two species of Ammonite have been found in the galt in this neighbourhood, by the author.

The Inoceramus Concentricus, and I. Sulcatus, commonly considered characteristic fossils of the galt, are found high up in the malm rock, by Mr. Edward Rhodes, at Amberly;—another proof of the community of character of the glauconitic series, and of the difficulty of prescribing arbitrary zoological distinctions in strata so nearly allied, and of such proximity.

On the opposite side of the river, another and smaller outlier emerges from the levels, and covers part of the parish of Wiggonholt.

North of these two, are other outliers, also emerging from the alluvium of the Arun, one of which is intersected by the London road, at Pulborough church.

Smaller wrecks of this formation may be observed elsewhere upon the sand country of this district, as at Tripp-Hill, by Fittleworth-bridge, Waltham Park, &c.; and several spots upon the barren sands seem to be fertilized by its débris.

## SHANKLIN SANDS.

It is unfortunate for a correct and consistent geognostic arrangement of this district, that two sands so distinct in their mineralogical and agricultural characters, and forming countries so diametrically opposite in general aspect and fertility, should be classed together. But the manner in which they run into each other, and in fact change places,* in other localities, and the inconstancy of their agricultural character, together with the strong similarity of their fossil remains, must be the excuse with the inquirer, who is not accustomed to the arbitrary arrangements of a stricter geology.

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* It is not meant that the lower green, or lowest bed of the Shanklin sand, actually takes the place of the ferruginous, but that beds of similar mineralogical character, are in some places superadded to the ferruginous. This is the case in the fuller's-earth country about Nutfield, where the green-sand and green-sand stone, which forms the coping of the fuller's-earth beds, can scarcely be distinguished from the lower green-sand; and being decomposed, forms a soil like it, and of equal fertility—a "hazel-mould."

The Shanklin sands are naturally divided into two groups, each forming a distinct country, and each expanding, like all the other formations in the circumference of the weald cavity, from the east westward; each also having a distinct line of demarcation, and a separate escarpment.*

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* Nothing can be more distinct than this natural division, from Hurstperpoint to the Lod. It afterwards becomes more obscure, and although there is a marked difference between the upper or ferruginous beds, and the true lower green-sand, all round the upper part of the weald valley, they are very much blended together. East of Leith-Hill, the true lower green-sand, as it appears on the south side of the valley, seems to be quite lost; but it is resumed again in Kent, and the writer has been favoured with the following observations by Mr. Murchison. "The calcareous beds of the lower green-sand are more largely developed in the neighbourhood of Boughton, than in any other part of the weald—they amount in some sections to 29, which are divided by the workmen into Kentish rag, kolksteen, &c., and the matrix, or intervening rock between these calcareous beds, is called hassock. This hassock becomes more prevalent in approaching the escarpment, and at Sutton Valence there are extensive quarries in it, which are not distinguishable from your Pulborough stone, or true lower green-sand. On the north of Maidstone, the ferruginous part of this formation is in its proper place, with overlying galt and firestone (*malm*)." Distinct groups have been observed by Dr. Fitton in the vicinity of Folkstone and Hythe. "The first and uppermost consisting of sand, abounding in irregular concretions of limestone and chert, sometimes disposed in courses oblique to the general direction of the strata. The top of this sand in the vicinity of Folkstone and Hythe, forms an extensive plateau, resembling that of the Blackdown range of hills in Devonshire. The second group of this formation likewise consists chiefly of sand, but in some places so much mixed with clay, or with oxyde of iron,

The upper, or *ferruginous sand*, occupies the broadest space in this part of Sussex, betwixt the chalk and the weald clay; the average being two or three miles. It sometimes rises into considerable eminences, which are often remarkably conical, as in Sullington Common; or stretching out into plateaux, like Longbury, Hurston, or Graffham heaths.

The beds of this stratum appear to arrange themselves in large masses, (like an affectation of a crystalline order on the largest scale,) alternating in colour, consistency and induration, and are every where highly ferruginous. Green-sand may sometimes be detected in them, but for the most part they are red and yellow, and sometimes white or black. They are pervaded with thin veins of ochreous clay, which, cropping out, give fertility to land that would otherwise be remarkably barren. Besides these veins, there are occasional subordinate beds of dark blue unctuous clay, having very much the appearance of galt clay, which may occasionally be seen cropping out upon the northern edge of the stratum. Such a bed, from five to ten feet in thickness, may be seen at Red-Hill, in the road between Bignor Park and Shopham-bridge.

The less indurated parts of the ferruginous sand are much broken up, and mixed with diluvial flint and fragments of its own-iron stone, rubble,

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as to retain water; and it is remarkable for the great variation of its colour and consistency, from the state of loose bright yellow, or ferruginous sand, to that of a dark greenish tough mass, like that of the cliffs of Shanklin and Black-Grange chines, which correspond to it in geological situation. The third and lowest group of the Shanklin sands abounds much more in stone; the concretional beds being closer together, and more nearly continuous."—*Annals of Philosophy, Feb.* 1827.

and a kind of clinkers (provincially, "rye-stones"*) a quartzose black iron-stone of great hardness.

Its common iron-stone† (car-stone) abounds most in the reddest beds of sand, and exists in balls,‡ large long hollow concretions, and tortuous veins, the latter of which appear to be an affectation of the lenticular or concretional disposition. This stone is largely quarried for building purposes, at Pulborough, Fittleworth, and in other places, and is a useful material for roads.

It has no limestone, nor chert; materials that so much distinguish the next group of Shanklin sand. Of the other distinctive characters of the ferruginous sand, the most remarkable are, the absence of all but the most trifling springs, and those chalybeate, and the free growth of peat-bog in all the low places, which are furnished with a copious soakage. The peat in this part of the country is peculiar to this stratum, and judging by the observation of this district alone, it might be supposed

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[*] Probably rhie or bryg, or hillock stones. The word is still retained in the Scotch "righ," or as it is improperly spelt, in "corn-riggs."

[†] A coarse quartzose sand, cemented by oxyde of iron.

[‡] The nucleus of these balls is often pyrites, or a ball of chlorite sand, and sometimes wood. Sometimes the concretions are cylindrical, as if they had been made around the stem of a plant, or some other organized body of that shape.

Masses of a conglomerate of this stone are to be found in one locality (between Hardbarrow and Thakeham). The fragments are mostly angular, and have been re-cemented by the same rich oxyde of iron, common to all the stone of this kind.

The unpractised observer must be aware of a great tendency in the rocky beds of this stratum, to exhibit what is called a false stratification, which, independent of their cleavage, is very deceptive as to dip and arrangement.

that the soakage of a chalybeate water is necessary, or at least most favourable to the growth of the aquatic plants, the basis of these peats.*

But notwithstanding the general aridity of this sand, as it has been observed by Mr. Murchison, it carries large ponds and considerable streams of water, supplied from the neighbouring strata.

It does not seem difficult to account for this phenomenon. The clay washed out of the adjoining countries, and deposited in the hollows of the sand, with the sediment of its own ochreous clays, would be sufficient to support these waters. But there can be no doubt also, that there is a clay stratum, interposed between the ferruginous sand and the lower member of the Shanklin sands, the "lower green-sand," which is the chief instrument in their maintenance.

The outcrop of this argillaceous layer is very much obscured, but by a careful examination, it may be detected in the whole line of country under review. It may be seen in an almost perpendicular section of the greater part of both sands at Henfield, east of the Adur.†

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* These moist places appear to be supported, like the ponds and streams of this district, by the argillaceous beds of the bottom of this stratum—the intervening beds of Dr. Fitton.

† Since writing the above, the author has been over the ground with Dr. Fitton, and is assured by him, that its affinity to the country about Hythe is very striking; and he thinks that the intermediate blue argillaceous beds merit to be ranked as a third or intervening group, as they do in Kent. But as they do not here form a distinct country, (although they seem to be the cause of the well-marked escarpment of the ferruginous sand,) and in general graduate so gently into the other parts of the Shanklin sands, it does not seem necessary to keep them apart. The section of Henfield-Hill exhibits the whole series.

The blending of the two groups begins immediately west of the Lod, and the marked difference of the upper and lower parts of the Shanklin sands, is only perceptible westward of

The gradation from the ferruginous sand with its iron-stone, down into the limestone of the green-sand, is well exhibited in the hollow way leading from the mill into the meadows at this place: the blue clay is found, with springs, below the sand and above the limestone. The same may be observed in the ascent from the lower common into the village, upon the Steyning road.—*(Vide Section.)*

The wells upon the escarpment of the ferruginous sand exhibit the same arrangement, being generally bottomed in what is locally called a " blue marl."*

This interposed bed of clayey substance varies a little in its progress westward; and below it, in the neighbourhood of Petworth, is an unctuous yellow clay, and perfect fuller's-earth.

Between Tillington and Half-way-bridge, in lands belonging to the

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that rivulet, in the sections upon the escarpment overlooking the weald clay. The course of the Lod is remarkable, as the commencement of this division, as well as an excellent example of the transverse fissure.

* All blue earths which flake and run by exposure to frost, like chalk, are called marl in this country. The galt in this way gets the name of marl, where it is not cretaceous.

This arenaceous blue clay has lately been bored 35 feet in a well of 30 feet at Pulborough; at which depth a sand rock was penetrated, and a copious supply of good water obtained, which rose 18 feet above the bore. This corresponds with the section at Henfield-Hill, and gives to the ferruginous sand, with its subordinate blue clay, a thickness of about 100 feet, allowing for removal.

The road from Sutton to Petworth affords a good display of the whole series:—The arid upper sand at Crouch common; the argillaceous, shaley and moist, between Shopham-bridge and Stroud; and from Stroud, on through Byworth, the green-sand, and concretional blue limestones.

Pitt's-Hill Estate, the most considerable beds of this mineral are to be found, and have thereabout been quarried for commercial purposes. They lie naked beneath the soil, and are supported by gritty green-sand. From this point, the same stratum is occasionally visible, and can be traced round by Lodsworth, at the foot of the ferruginous sand, up to Bexley and Henly Hills, north of Midhurst.*

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* *Organic Fossils of the Ferruginous Sand:—*

Patella.
Rostellaria Parkinsoni.
Natica?
Dentalium.
Mytilus.
Modiola imbricata.
Tellina.
Cucullea decussata.
Trigonia clavellata.
——— aliformis.
Venus.
Crassatella.
Venericardia Planicosta?
Mya intermedia.
Pecten quinquecostata.
Perna.
Terebratula ovata.
————, a small striated species.
Echino-spatagus.

*Mantell.*

*By the Author, and for the arrangement of which he has to thank Messrs. Sowerby and Murchison.*

Univalves :—

- Auricula—species not published.
- Rostellaria—3 species, of which one is R. Parkinsoni, (also at Lyss, by Mr. Murchison.)
- Turbo?—imperfect casts of.
- Natica—formerly Ampullaria—the same at Blackdown, and near Devizes, and a Lyss, near Petersfield.

The lowest member of the Shanklin sands, the "*lower green-sand,*" next succeeds, and forms, as before observed, a distinct country, almost

**Bivalves** :—

1. Avicula—new species.
2. Ditto Ditto.

*A new Genus, resembling Avicula, but differing from it in having a gaping shell—has been named in Germany.*

1. Cardium?

1. Cucullea Decussata—(Sow. t. 206.)
2. ——— a new species.

1. Corbula—a small species common in the green-sand.
2. ——— new species, wider than the former.

1. Lenia—not yet figured—found also by Dr. Fitton, at Folkstone.

1. Lucina—species Globose, also by Mr. De la Beche, in Dorsetshire.
2. ——— new species, of which the striæ are small.

1. Modiola—The same species is in Mr. Sowerby's Collection, but has not yet been named.

1. Mya Plicata—(Sow. t. 419.)

1. Mytilus Edentulus—(Sow. t. 439.)

1. Nucula Impressa—(Sow. t. 475.) Blackdown.
2. ——— new species.

1. Orbicula—new species not published, beak central, and therefore unlike O. reflexa.

1. Pecten Obliquus?
2. ——— new species, not figured.

1. Pinna—fragments of, (found also by Mr. Murchison, near Petersfield.)

1. Tellina Æqualis.
2. ——— a new species.

1. Thetis Minor—(also at Lyss, near Petersfield: the same is in the Pulborough stone, or lower green-sand.)

equal in magnitude, and superior in elevation to the foregoing. It consists, in its superior parts, of alternations of green-sand, of various

1. Terebratula lata—(Sow. 502. fig. 1.) from Devizes.
2. ——— new species.

Trigonia—(also at Lyss.)

1. Venus parva—(also Lyss.)

Casts of Echini—Vermicularia concava—(Sow. t. 57.)

*From the lower green-sand, or lower group of the Shanklin sands.*

Ammonites—3 species—(also by Mr. Murchison at Boughton, in Kent.)

Nautilus.

Bivalves:—

1. Inoceramus—new species—(also found in Dorsetshire, by Mr. De la Beche.)
2. ——— ditto—(also Isle of Wight.)
1. Mya Mandibula—Sow. Devizes—(also at Boughton.)
2. ——— new species.
3. ——— ditto—(also found by Mr. De la Beche, but not figured.)
1. Pecten orbicularis—(Sow. both valves.)
1. Pholadomya—new species, much resembles the cardita tuberculata of green-sand near Devizes.
1. Trigonia spinosa—(Sow. t. 86.)
1. Thetis minor—(Sow.)
1. Venus parva.
2. ——— a new species.

Echini.—Wood.

*The most remarkable circumstances respecting these fossils are—*

That the ferruginous sands are destitute of them except in one of their lowest beds, in which they are disposed in nodules, or lenticular masses, clustering together in great confusion, and like a ferruginous conglomerate of casts of shells. These nodules crop out hardness, with nodular and lenticular masses of blue limestone,* becoming occasionally tabular courses. The inferior beds lose the limestone, and become more compact, and finally accompanied with chert, and graduate with thin layers of loose green-sand into the weald clay.

This stratum rises at two points from the alluvium of the Adur,—in the form of an outlier at Ashurst,—and in a narrow slip of land, comprised in the farms of Wickham and Huddlestone, north of Steyning. From the latter point, it runs westward, by Wappingthorn, and rises

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in several parts of the escarpment of the ferruginous sands, but particularly in the Park-Mount-Lane, at Pulborough, and at Chiltington Common. They are also easily obtained at Sparright in Parham Park, in the retroverted mass to be described in another part of this memoir.

Wood is sometimes found in the nucleus of these nodules.

There is also a great variety of shells in the lower green-sand, but they are more widely dispersed. The most frequent and most characteristic are the pholadomya above-mentioned, and the pecten orbicularis; the latter of which is the characteristic fossil of the upper green-sand, or malm. Adverting to this circumstance, Mr. Murchison observes, in a letter to the author, "that the calcareous beds of Boughton quarries, in Kent, have so strong a resemblance to the compact blue beds of the malm rock, that in hand specimens they might be taken for it; and like your lower beds, they also contain the pecten orbicularis, the characteristic fossil of the upper green-sand—(firestone or malm-rock)."

* This concretional limestone seems to be the equivalent, in this part of the country, of the Kentish rag. It is an arenaceous limestone, but finer grained than the Bargate stone, and not so crystalline as the rag. It decomposes rapidly, and is a bad road-stone. In this part of the country also, it often resembles the indurated malm.

These blue beds are particularly fertile in the pholadomya, pecten orbicularis, trigonia, &c., about Thakeham and Nutbourne. And at Bognor Common, in Fittleworth parish, there is a vein of friable green-stone, rich in the pecten, trigonia, and a crustaceous fossil, like the shrimp.

into a considerable eminence in Chancton farm. Then crossing the Worthing road, it is carried on in the remarkable rent, to be hereafter described; and, in another cant, is suddenly projected northward, to form the high grounds of Warminghurst, Thakeham, Chiltington, and Pulborough, and the still higher and bolder hills of Petworth and its vicinity.

Where it emerges from the levels of the Adur, nothing appears but the loose green grit* of this formation. The first section in which the limestone beds appear, is the quarry behind the malt-house at Ashington, where they alternate with the grit-stone, and this alternation is continued in the upper beds throughout this district; the concretional courses sometimes affecting the nodular and lenticular, and sometimes running into the tabular arrangement. In their progress westward, also, the lower beds of sand become more compact, and are quarried at Pulborough and Petworth, for excellent building stone. At the former place, pits are now open, that were wrought by the Romans. West of the Arun, the same beds become less compact and argillaceous, as at Bognor and Brinkshole Heath, and pass into the brittle and cherty layers of Bedham-Hill, and the eminences above and beyond Petworth. Seams of yellowish brown clay often occur between the courses, which sometimes contain an impure fuller's-earth.†

The depth of this part of the Shanklin sands is variable, but the average can scarcely be less than 150 feet. Wells near its northern escarpment vary from 30 to 70 feet. That at Cecilroy farm, north of Fittleworth, is 110 feet.* And the inverted mass at Jacquet's-Hill, in Thakeham, gives a depth of at least 150.

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* The term *grit* is here used, as it is provincially, for a friable coarse-grained sand-stone.

† In most of the sections about the hollow ways of Thakeham, Pulborough, Fittleworth, &c.

The strong contrast in the agricultural character of the two members of the Shanklin sand has already been mentioned. The sterility of the ferruginous sands is only occasionally relieved by the remnants of the

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* *Well, and borings, in the garden behind Petworth-House.*

| | Feet | |
|---|---|---|
| Part of the *Glauconite.* | 16 | Sandy loose rock. |
| | 2 | Whin (chert?) |
| | 35 | Sand-stone, sand and whin. |
| | 5 | Whin. |
| | 7 | Rocky sand. |
| | | (Water.) |
| | 35 | Black sand. |
| | 15 | Brown sand. |
| | | (Water.) |
| Part of the *Wealden.* | 281 | Clay. |
| | 1 | Pyrites. |
| | 3 | Greenish-grey sand. |
| | 400 | |

This perforation proves highly satisfactory, in a geognostic view, although it did not answer the purpose for which it was intended.—It measures the thickness of about half the lower green-sand, (Petworth-House standing in an eroded notch of that stratum,) and of the whole of the upper bed of the wealden; the four last feet being unquestionably in the first or uppermost bed of Wealden sand.—(*See Perpendicular Section, Plate* I.)

Greenish-grey sand was lately taken out of this bed at Mulsey.

galt, and other adventitious soils; the remainder forms extensive sandy commons. Whilst all the tract of the country of the lower green-sand, from Wiston, where it emerges, to the Lod, is as remarkable for its fertility,—its detritus being a light loam, which forms, particularly where the limestone abounds, the finest barley land in the country. The springs also of this stratum, may vie in purity and copiousness with those of the chalk or the malm.

### *Extract of a Letter from* Dr. Fitton, *upon the Sands of the Eastern part of Kent.*

"My excursion with you in the vicinity of Pulborough, has confirmed the opinion which occurred to me on first hearing your paper—that the structure of your country is the same with that of the vicinity of Folkstone. From what I have seen indeed with you, I should say, that geological identity is seldom more complete than that of these two tracts, which are at least seventy miles asunder.

"The chief distinctions between the districts (so far as I have seen) are, that the upper portion of the sands near Pulborough, contains less stone than in Kent, where the beds of a loose concreted calcareous grit, containing petrifactions, and passing into chert, form a considerable part of the upper of my groups.*

"The '*false stratification*' (as it has been called) of the sands at the top of this formation, appears to be remarkable near Pulborough:—in Kent, it is very conspicuous; and, what is singular, the concretional masses of chert and limestone, assume also this *false* arrangement, as well as the sands.

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* Dr. Fitton here refers to a detailed account of the country about Folkstone and Hythe, with maps and sections, read by himself before the Geological Society in December last.—*See Annals of Philosophy, March,* 1827.

" Your second group appears to me to coincide completely with mine. It contains clay, is variable in colour, and retains water in many places.

" The third or lowest group, which contains your Pulborough stone, abounds in Kent also, in firm, and frequently continuous beds of ' Kentish rag,'—the fossils of which, on the coast, and in all the range of the interior, are the same with yours. The passage from these solid stony beds, into the loose sands of the middle group, is in Kent, as with you, marked by concretional nodules of great bulk, which are insulated in the sand;—or, speaking in the order of formation, the concretional process becoming less productive, (or the concreting substance less abundant,) the lower beds are stone in continuity; while in those above, the concretions are less numerous, and partake more of the character of sand.*

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* In reference to the concretional action spoken of by Dr. Fitton, the order in the Pulborough district is this:—The lowest beds, the quarry-stone of Petworth and Pulborough, are a moderately compact green-sand stone, have no concretional masses, and exhibit no signs of calcareous matter. The next above, answering better to the 'Kentish rag,' have calcareous concretions, occurring sometimes insulated, and sometimes running into continuous layers; and then again, higher up, they become more and more rare, till the matrix only is left—a friable mass, graduating into the argillo-arenaceous beds of Dr. Fitton's intermediate group, or the lower part of the ferruginous sand of this memoir.

" The same structure, and proportion, pervade the whole tract between the chalk and the weald clay, at least as far as Maidstone; near which place the Boughton quarries have long been celebrated, as affording in great abundance solid and useful stone. And the stratum which supplies the stone at Boughton, is continued from the quarries of Sandgate and Hythe, at the lower verge of the sands. But in some of the intermediate points (as near Ashford), the stone is at present wanting, having been either not deposited, or subsequently carried away; —so that the moist and flat tract of the middle group of the sands is not there separated from the weald by any prominent ridge. But I have very little doubt, that a close examination of the strata of Kent will show, that the general structure and proportions are uniform throughout; and your work will demonstrate that the vicinity of Pulborough is a continuation of them.

" It is highly probable that a re-examination of the coasts of the Isles of Wight and Purbeck, (which I have not seen since I last examined that of Kent,) would prove that the triple division of the lower-green (Shanklin) sands may be detected there also. The fossils, certainly, of the lowest group in the Isle of Wight, where large knobby concretions abound, are precisely those of Hythe and Pulborough:—but there is one very abundant fossil of Kent and the Isle of Wight, which I have not seen with you,—a very large and characteristic gryphite—the gryphœa sinuata."

# WEALD FORMATION, OR WEALDEN;

*Including the Weald-clay, Hastings-sand, Iron-sand, and Tilgate-beds, of various geological writers.*

The transition from the green-sand to the weald clay, is not so sudden but that alternate layers of both substances may be observed, and a gradation of one formation into the other.* The junction is also marked in some places by calcareous concretions, with broken ammonites, and other imperfect fossils.

The escarpment of the green-sand is every where prolonged by a considerable slope of the adjacent clay, and this is gradually heightened from the Adur westward, through all this line of country; the elevation of the clay basis being always proportionate to that of the green-sand hills.

Besides this slope, there is from the bottom of the green-sand a breadth of from a quarter to half a mile of clay, giving together an average depth, perhaps of 150 or 200 feet. At a moderate depth from the surface, this clay is generally blue, running into layers of hard blue shale, often impressed with the cypris faba; and containing nodular concretions in concentric layers of ferruginous clay, sometimes containing calcareous matter. These argillo-calcareous septaria are sometimes coated with a ferruginous concrete, containing casts of shells of the genera cyclas, cyrena, and paludina, with the cypris faba. At the top of this stratum, also, at its junction with the green-sand, in one locality, the author has discovered large bones of vertebrated animals,* enclosed in a ferruginous concrete of sand and clay, but too imperfect to be appropriated.

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* This mixture and alternation varies very much in thickness. It is very trifling in the eastern part of the district, but increases rapidly westward. It may be studied well upon the northern slopes of Bedham-Hill and Flexam Park, and is there about the same thickness as in the well at Petworth-House, fifty feet.

At the bottom of this first layer of the weald clay, appears the first bed of sand, of which the thickness is uncertain. Sections have been made in it to the depth of twenty or thirty feet, and it is probably as much more. It is a brownish-yellow micaceous sand, abounding in white argillaceous veins, and with a coarse iron-rag,† sometimes containing casts of cyclades, the teeth and scales of fishes, and vegetable impressions,‡ and in every respect assimilating to what has been hitherto considered the true Hastings-sand. The course of this bed of sand has been particularly attended to, and it has been traced through all the line of country here attempted to be described. From Mulsey, (in the line of section of the Arundel and Bognor-road,) tracing it westward, it may be found at Bignor-farm, under Bedham-Hill, Buckfold, Parkhurst, Lickfold, and within half a mile of Blackdown, near Lurgershall, where there is a fine bank of it exposed at Northhurst-farm. Eastward, it runs by Willets and Spear-Hill, and crosses the Worthing road, at Wincaves; from whence, its course is a good deal disturbed by the disruption of the Vale of Greenhurst; but it is found at Jessups, and again, a little north of Henfield.*

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* At Henfield, between the village and the turnpike-gate, on the Horsham road, associated with vivipara.

† The sand is sometimes sufficiently indurated to form a building stone. And the iron-rag frequently becomes a conglomerate of sand and clay, with angular, and sometimes slightly rolled fragments of chert and sand-stone. It has been extensively quarried in this part of the country, anciently, for smelting.

‡ A specimen of *Endogenites erosa* from this course of sand, was found near Mulsey, and is now in the possession of Mr. Sowerby. It measures about ten inches in length, and six in circumference, and has lost a few inches at its apex. At the base, it is broader than that figured in Mantell's Tilgate Forest. The petrifying matter is silex.

From this bed of wealden sand, to the first course of Sussex marble, is a breadth of about half a mile of blue, brown, and red clays.

As the wells in this part of the weald find water at from thirty to fifty or sixty feet, and as it can seldom be obtained without entering an arenaceous bed, or a course of marble, the thickness of the clay may be rudely estimated at more than the highest of these numbers. Attempts to establish wells immediately behind any of these courses, are generally abandoned before a sufficient depth is attained to penetrate the next stratum.†

The first course of the well-known calcareous concrete of fossil shells of Helix, or Vivipara, called Sussex marble, varies in thickness from two to ten inches. Sometimes it is divided into two thin layers; at others, it is concreted in one. In this part of the country, it seldom contains any other petrifaction than its peculiar univalve.* Fibrous carbonate of lime is found in it, and it is surmounted by a course of blue marl, which effervesces strongly with acids. It forms a tolerable road-stone in a country almost destitute of such materials.

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* The irregularity of the denudation between Warminghurst and Henfield, seems to have left outliers of this sand, as well as of the upper bed of weald clay, out of the usual course, in that line of country.

† A well lately dug at Scrub-House, under Bedham-Hill, and below the first course of wealden sand, gave the following results:—

This course of marble may be distinctly traced through the whole line of country, from midway between Kirdford and Lurgershall, in the west, by Battlehurst and Marshalls, to the Arun, and by Pococks and Hungar-Hill, Hammer-pond-tail in Shipley, and Sands in West Grinstead parish, to the Adur.

Another succession of clays, of much less depth than either of the former, then presents itself, and then a second bed of sand more mica-

| *Feet.* | |
|---|---|
| 12 | Reddish clay, without admixture of any sort. |
| 1½ | Marble. |
| 44 | Blue clay, and shale, with selenite in profusion; Cypris (apparently two species), and fish scales; clay indurated, and often passing into blue fuller's-earth, like that found by Dr. Fitton in the "Hastings-sand," upon the coast of the Isle of Wight. |
| —— | |
| 57½ | |

From subsequent observation, the author is led to believe, that the depth of the second bed of clay, or that interposed between the first course of sand and first course of marble, is somewhat exaggerated in the perpendicular section. It is probably not greater than the one next below.

On the north side of the weald, these courses are all thinner, and being thrown up at a sharper angle, come much closer upon each other. Upon Earlswood common, near Reigate, in Surry, about half a mile or less from the Shanklin sand at Redhill, by the Brighton road, the highest stratum of marble crops out, and the course of sand is to be observed within a few yards above it.

* A specimen has since been obtained, containing a fragment of a cylindrical bone about four inches in length, much compressed. This specimen is also very full of the cypris.

ceous and of a deeper brown, and with less admixture of clay. In this course of sand, are found occasional beds of flat calcareous grit-stones, having all the character of the Horsham stone.* Paving stones as fine as those of Stammerham, have been quarried at Andrew's-Hill. From this point the sand has been traced westward, in the several localities of Lee-farm, Haresfold, Lowfold-sand-coppice, in Wisborough-Green parish; Alfold by Isleham-bridge in Kirdford, and Eberknoll: eastward by Butterstalks and Knepp Castle, in Shipley, to Jolesfield Common; and in these several places, it is often quarried for road-stone. No fossils have as yet been discovered in it.†

Next succeeds, about a furlong north of the last-mentioned sand, the thickest and finest bed of Sussex marble, of which a quarry is now open at Slaughter-farm, and is unquestionably that which skirts round by Kirdford and Plaistow, and which used to furnish slabs for architectural purposes. At Slaughter-farm there are four layers, nearly alike in texture, separated by lines of a black ferruginous matter, and making in all about eighteen inches.

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* Some of these flag-stones have smooth surfaces, others are furrowed, or wavy. The latter appearance has been attributed to the action of retiring waters, like the wavy surface of some parts of the strand at low water. Those persons who discovered the similitude, forget that the stone in question is not a sand, but a crystallized carbonate of lime, of fresh-water origin. Such conceits do not come well from the Geologists of the present day, who affect to be purely practical.

† The well at Shipley workhouse being supplied with a brackish water from this stratum, attempts were lately made to obtain a better, and a perforation was made by digging 75 feet,
Boring 35
110

In the middle of the boring, a thin shelly stratum was perforated, and again a thicker one at the bottom; these were the lowest courses of Sussex marble. No water being obtained, it was abandoned. From 50 to 100 feet more would have been necessary to reach the next sand. But the hard shale and concretional clay-stone of the intermediate beds, sometimes carry water enough for a moderate supply.—This is the well mentioned by Mr. Mantell, *Illust. of Geol. of Sussex, p.* 25.

Besides the vivipara, this course of marble contains a delicate bivalve unnamed fossil, and teeth and palates of fish; and it reposes on a highly compressed dark blue shale, that effervesces with acids, and is filled with impressions of the cypris faba.

There are then beds of blue and red clay, and a third course of fawn-coloured micaceous sand, carrying a thin slaty sand-stone of a remarkable foliaceous fracture, and full of mica. This course crops out at Parbrook-Hill, south of Billingshurst, and appears at Barkfold, in Kirdford parish, and Newbridge; and eastward, in the north part of Shipley and West Grinstead parishes.

Immediately below this course of sand, a thick bed of red clay succeeds, and then the calcareous grit, sand-stone, and clays of what has generally been considered the "forest range" of the weald.

By this sketch of the contents of this part of the weald, it will be seen that there are two distinct beds of sand above the Sussex marble, the highest of which has all the character of the "Hastings-sand," and the second carries Horsham grit.

There is therefore no line of demarcation to distinguish the Weald from the Hastings-sands and clays; except a slight elevation of the line of country, a more stony structure, and greater sterility.* If there is any thing more in the soil that marks an entrance into the forest range, it is the thick bed of red clay, which may be traced skirting round from Loxwood, by Wisborough-Green and Parbrook-Hill, in Billingshurst, into Shipley parish. But this red clay is found in greater or less quantity, above all the sandy and stony strata of the weald clay, properly so called. It is also worthy of observation, that all the principal beds of stone are surmounted by blue marl, from one to three feet in thickness, and rich in calcareous matter.

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* From the high grounds upon its borders, the centre of the weald presents a range of gentle elevation, when collectively viewed; but when examined in detail, it is impossible to say where the line of elevation begins. Plaistow-place is the highest point in the western extre-

Besides the courses of sand and stone above described, there are occasional beds of clay iron-stone, useless for road stone, and therefore not often disclosed, although they were anciently wrought and smelted at the several *furnace-ponds* and *hammer-ponds* of this country; the slag from which is every where to be found in its roads.

The lowest bed of marble is not often sought for, because of the vicinity of the limestone-grit,* and therefore its course has not been

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mity of what is called the "forest ridge," and it is its apex. It is in the line of the third sandy course, (reckoning from above downwards,) but the country for miles around it is all alike, and the natural features nearly the same. In the eastern part of the weald, the more stony structure may have brought out this ridge, and made it a natural feature; but in the west there is no such marked distinction. Take for example, the line of section upon the Map which accompanies these remarks: a gentle rise marks the first course of sand at Mulsey; another, the second sand at Andrew's-Hill; and a third, the last at Billingshurst. The firmer parts are brought out every where by the erosion and removal of the intervening and more destructible.

* This course has occasional interruptions, arising, undoubtedly, in part from the large drafts made upon it for domestic purposes, as far as it has been accessible, and would pay for removal. If not entirely wanting, in the line of country from Kingsfold in Billingshurst

traced far upon the Map. No more of this peculiar concrete is found below the third course of sand, but a thin subordinate stratum has been detected in one locality between the two principal ones.[†] Subordinate arenaceous veins are also to be found, some of which carry thin calcareous stone; and which may be generally detected, as all the sands may, by the occasional growth of elm-trees. This agricultural test may be depended upon in all this part of the weald, except where there are diluvial deposits.[‡]

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parish, to Steers Common in Kirdford, it is so thin, or so deep, as not to be worth seeking. But its equivalent has been found between Wisborough-Green and the sand of Haresfold, and is there a similar stone, without fossils. A long and broad line of it is then traced from Steers Common, northward by Plaistow, and is the course which comes round on the north side of the weald, by Rudgwick and Ewhurst.

[†] Between Slaughter-farm and South-House, and perforated at Shipley workhouse.—(*See note, p.* 44.)

[‡] The writer is indebted for this notice to the observation of a gentleman long conversant with the weald, and it is very much to be relied upon in the wide clayey districts. Sometimes these elms are seen clustering about a farm-house, the site of which seems to have been determined by the drier elevation of one of these arenaceous beds, and the greater facility of procuring water about them. But it is not certain that these beds are not outliers from the regular courses; many of them certainly are.

The lover of natural history will be led to the observation of many interesting phenomena like the above, arising out of the mineralogical characters of the soil. For instance, the botanist will find the lanes of Shipley full of the pretty dwarf shrub, the Ononis arvensis; he loses it in the Shanklin sands, and finds it again in the galt at Washington Common; and a third time, after crossing the chalk-hills, upon the plastic clay at Goring or Patching. And the picturesque-traveller who descends into the New-Woods, (galt of Bury and Bignor,) in a fine spring morning, will suppose himself already in the depths of the weald, for no where else are the roads so execrable, the oaks so thick, and the nightingales so numerous.

# DILUVIUM.

The diluvial beds of this part of Sussex are few and of small extent, and, from their loose and porous nature, badly preservative of organic

### *Fossils of the Wealden.*

The fossil shells most frequent in this district of the weald, (and they are common to the whole Wealden,) are of the genera Vivipara, Cyrena, Cyclas, Cypris, and Paludina. Vegetable impressions are found in the sandstones; and bones of vertebrated animals, in all parts of this formation, from the top of the weald clay downwards. Bones of Lizard or Saurian animals were found by Mr. Murchison at Loxwood, and have been lately obtained from the pits at Billingshurst. From the same neighbourhood was lately obtained a fragment of a fish, comprising the gills, and forepart of the body, and measuring nine inches in length, seven in breadth, and five in thickness. It is thus spoken of by Mr. Konig, of the British Museum, to whom it has been exhibited. "It appears to be one of those species of *Esox* of Linné and other writers, of which a genus has been formed by Lacépède, under the name of *Lepisosteus.* The disposition of the rhomboidal scales[*] of the upper part of the body, is exactly like that of the same parts in *Esox osseus* of Bloch." The mandibles are wanting in this specimen.

Three species of unio have also been found in the lower marble at Plaistow.

" *Fossils of the weald clay.*

Scales and bones of fish.
Tooth of Crocodile.
Cypris faba.
Vivipara fluviorum.
———— extensa.
Cardium turgidum.
Melania attenuata.
———— tricarinata.
Cyrena membranacea.
Paludina elongata."

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[*] Scales exactly corresponding with the scales of this specimen, have been found in the first course of Wealden sand, under Leith-Hill, in Surry.

remains. None such have been discovered, except impressions upon flint.

The diluvium for the most part assimilates to the strata upon which it rests, being chiefly composed of their detritus, with the admixture of materials derived from the superior ones. Thus, the washings found upon the malm are chalky and marly, and sometimes lie in beds of six or eight feet in depth, upon the malm country, and upon the upper part of the galt.

Pinna.
Venus.
Potamides? *Mantell.*

To these Dr. Fitton adds ostreæ—and another species or two of paludina, and observes, that the most of them are to be found in the Hastings sands, formations also. "And in fact, if a line be drawn between the green-sand (glauconite) and weald clay, the whole series from thence downward to the Portland limestone, may be regarded as one great suite of fresh-water formations;—with the exception principally of those beds of oysters which occur in small proportion in the weald clay, and more remarkably about the middle of the Purbeck strata."—*Annals of Philosophy, Nov.* 1824.

The author of this Essay finds that a line of blue shale runs all along the upper part of the clay in this part of the country, abounding in some of these fossils, and in ferruginous septaria, which are coated with a conglomerate of casts of paludinæ, cyclades, cypris faba, and bones of fish, and perhaps of birds. For researches on this part of the subject, in the forest range, or central nucleus of the weald, the reader is referred to the highly interesting details of Mr. Mantell, who has proved the existence there of the remains of plants and animals of unknown and extinct species, but assimilating most to the productions of tropical climates—gigantic palms, and as gigantic animals of the Lizard kind, that must be supposed to have been the inhabitants of the marshes of such regions; Ichthyophagous and herbivorous animals, whose necessary food would be the productions, of which the remains are still visible, and amongst which they are found.

The diluviæ of the ferruginous sands are chiefly composed of loose sand, with flints, and fragments of cherty stone, a coarse sand-stone, like that of the catacombs in the neighbourhood of Paris, and other stones supposed to be derived from the beds above the chalk, with fragments of the iron-stone of the ferruginous sand.* In the firmer parts of the sand, these diluvial flints and other stones are lodged in hollows, evidently of aqueous origin. In the clay country there is less diluvium, although it is by no means destitute of it. A great deal is lodged under the protection of the eminences at the upper end of the valley, from Lodsworth, round by Lurgershall, to North Chapel. It contains a good deal of the mouldered materials of the green-sand with its chert, mixed up with rounded fragments of iron-rag. Large masses of the chert of the lower green-sand are found also, scattered upon the surface of the clay, through all this district, within a mile of the green-sand escarpment.

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* Fragments of stone, which most resemble parts of the "calcaire grossier," from above the chalk, are to be found in all these diluvial deposits. And large masses of the conglomerate underlying the plastic clay, as it is found at Newhaven, and at Horsley in Surry, and many other places, above the chalk, are in the author's possession, taken from the diluvium by the river-side at Waltham, and from the galt at Wiggonholt.

The beds of diluvial flint, mixed with iron-stone, found upon the ferruginous sand (upper part of Shanklin sand) have been noticed by Mr. Murchison, and his observations upon them apply to this district also.

Although diluvial flint is rarely found upon the clays, there are some exceptions. A considerable sprinkling exists upon the clay between Ashington and Ashurst; but large deposits are found upon the sandy country, and must be supposed to have been detained there by entanglement in it, during the impetus of diluvian action, when every thing was swept along the slippery surface of the clay.

But the largest diluvial deposits are found in the vicinity of the river fissures, and present many substances interesting to the local geologist. Besides those above-mentioned, as found upon the ferruginous sand, large masses of a ferruginous conglomerate occur, with rounded and angular flint imbedded; rolled lumps of blue clay and half-concreted masses of sand and gravel, which do not appear to belong to any of the strata below the chalk; and flint also, which is very unlike the chalk-flint of this district.

## ALLUVIUM.

The homogeneity of the alluvium* of the Arun, (the only modern deposit in this district worthy of notice,) from the chalk-hills northward, is not likely to be much disturbed till after passing the stony strata.

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* The division of drift earth and stone into the two kinds here specified, is perhaps the best that can be made at present:—Diluvium, the washings of ancient, and alluvium, those of modern waters; the former, the "terre de transport" of the French. The only good objection that can be made to these terms, is, the difficulty of distinguishing the kinds of drift, and separating them from each other, and defining their limits. In the valleys of mountainous countries, in particular, this difficulty must be felt. The *Levels* of our southern rivers, the *Straths* and *Carses* of the Scotch, and the *Thalweg* of the Germans, must, for the most part, be based in diluvium, although they are coated with alluvium, or the detritus (*débris*) of their borders.

The alluvium of ancient waters will often be found, also, with diluvium, as well as the diluvium or drift of ancient changes. But these, when stratified, are easily known, and when not stratified or mineralized, can be distinguished by position, and other contingent circumstances.

It is for the most part the washings of the weald clay, and nothing is known of it but its superficies.

Above the defile of the green-sand at Stopham, trunks of trees in great numbers are discovered in it. They are oak, in a carbonized, but not bituminous state.

In early ages, when this part of the course of the river must have had more of the character of a ravine, with banks precipitous and woody, bordering a marshy area, the falling-in of an overgrown tree in times of flood, and its speedy envelopment in drift, would be a frequent occurrence. A great majority of these would be uprooted by westerly winds, so that the circumstance of their lying very much in one direction, does not presuppose any great natural catastrophe. Of the rate of accumulation in later times, in a part of the levels not the most favourable for deposit, some idea may be formed from the circumstance of a silver denarius of Antoninus Pius having been found a few years ago, in digging a hole at Hardham, about thirty inches below the present surface. As it was solitary, and not accompanied by any other relic, it is probable that it was dropped upon what was then the surface of the soil.*

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* For some account of the rivers and valleys of this district, see "Theory of derangement and denudation."

# THEORY

# OF

# DERANGEMENT AND DENUDATION.

THE geographical surface of this district corresponds very much with the order of superposition of its strata. The range of chalk-hills running longitudinally east and west, is succeeded by a series of terrace-like undulations, the truncated extremities of the malm beds, following the same order; and these again, by a surface rather wavy than hilly,—the narrow country of the galt. From thence arise the varied sandy sweeps and hillocks of the upper beds of the Shanklin, intersected by the rivulets of the neighbouring strata, but contributing little to them; and then again, the fine and more regular slope of the lower green-sand, or lower bed of the Shanklin sands, which, presenting for the most part a bold escarpment to the north, and overlooking every thing north and south, but the chalk-hills, is suddenly cut down into the clay valley of the first bed of the wealden. In this clay valley, undulations may still be detected running east and west, in an order corresponding with the position of its truncated courses; and these undulations become more and more marked as the stony beds of the deeper wealden become developed, every where intersected, and moulded into woody hills and dingles, by the water-courses which traverse them;—the history of which water-ways, taking, for the most part, their courses transversely to the longitudinal arrangement of the strata, displays the most interesting features of the whole weald, and is the illustration of the mode of its formation.

These several ranges of eminences are intersected by the great vallies of the river outlets, toward which the lesser depressions converge. These outlets, though wanting the precipitous cliffs and bold features of more mountainous and more rocky countries, have, in the eye of the geologist, the greater charm of being strongly illustrative of the great changes which the surface of the globe has undergone; and for this part of it, are also demonstrative of precisely the degree and mode of the last change that came over it, and left it what it is.

But as the disposition of the hills, valleys, and water-courses of this district, and the other great geological features of arrangement, or rather dislocation and derangement, of all its parts, have one common character, and all combine to illustrate a theory of the weald denudation; it will facilitate their description, as well as their better comprehension by the reader, to premise a slight sketch of that theory, and of the conclusions which are to be drawn from the appearances themselves, when comprehensively viewed.

The convenience of this reversal of the order of research will be sufficiently apparent, when it is understood, that although any considerable segment of the circle of the weald valley may be taken as a specimen of the whole, and will be found to contain all its illustrative phenomena; yet no part can be satisfactorily considered, but in combination with the remainder. The weald valley, or, geologically, the weald denudation, is understood to be bounded on each side by what are called the chalk-basins of London, and Hampshire or the Isle of Wight; between which it lies like a trough or gully, or like a third basin, elevated between the other two, and draining its waters into them, through cracks or channels in its sides.

Although the contents of these chalk-basins have been carefully examined and described, no satisfactory explanation of the mechanism or mode of formation of the basins themselves has yet been given. And since the French naturalists first made use of the term, so much laxity has obtained in the application of the word basin, that it is made to comprehend almost every depression in the earth's surface. Sometimes it signifies the bed of a sea, and we are told of the " basin of the Atlantic;" sometimes it comprehends continents as well as seas, and we hear of the " great European basin;" sometimes it is the course of a river, and sometimes it is the area of a local formation. In this latter sense, the French naturalists seem first to have used it. But having described the contents of that area, they do not seem to have formed any very precise notion of the constitution and mode of formation of the containing cavity, and we are left yet to discover, whether, by a chalk-basin, they mean an original concretion of that mineral in the basin shape, or the excavation or erosion of a cavity in it by water, or the contortion of a flöetz stratum, by subsidence in one part, and elevation in another.

The obscurity in which this branch of the subject has been left, appears to have arisen from the difficulty of considering it apart from a general theory of displacement, and from the conflicting opinions prevalent upon that subject; and because geologists, not professed vulcanists, have been in the habit of considering all displacement as the effect of one of two causes—of subsidence from simple gravity,* or excavation by watery erosion. In the constant repetition of the term chalk-basin also, it has been forgotten that the chalk itself is only an intermediate layer in a succession of basin-shaped strata; that the formations superincumbent upon, and subjacent to it, have a conformable disposition; and that therefore it is just as correct to call them London-clay, green-sand, or galt basins, as chalk-basins.

But in whatever mode these basins exist, they have been considered as the recipients and continent cavities of successional deposits of different æras, and different agencies. And their pre-existence is necessarily involved in that consideration. How far this theory agrees with appearances developed by later discoveries, remains to be proved. Some relaxation of the original idea of deposits in the Paris basin, exclusively, is said to have been made,* and the discovery of the same strata elsewhere, in a horizontal, and what may be considered an original position, serves to strengthen the opinion, that the strata above the chalk are all of a date anterior to the convulsion which divested it of its flöetz character.†

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* The effect of subsidence from gravity and compression, continues still to be overrated. It is even to be doubted if any displacement from these causes ever could take place, like the settlements of a building, to which it is often erroneously compared. The illustration is not only not a proof, it is not even a good illustration: there is no parallel in the cases. Deposit from water, whether crystalline or mechanical, would be as compact in the first instance under the pressure of an ocean, as it would be when covered by subsequent additions of a more solid nature. The same may be said of the erroneous conclusions respecting desiccation and contraction. All the great masses of the crust of the globe carry as much water now as ever they have done since their consolidation. The surface exposed to the action of the atmosphere will dilate or contract, according to its dryness or humidity; but all below the mere surface remains the same, whether above or below the level of the sea.—Mountains do not dilate in rainy seasons.

Some approach to this opinion seems to be entertained by those naturalists who have lately ventured upon the supposition, that the two basins of London and Hampshire have been united. Of the nature of that union, and of the state of things anterior to their disjunction, we are as yet but imperfectly informed.

It is not the purpose of this Essay to go into a consideration of the theories of the elevation or subsidence of whole continents; or of the connexion between the protrusion of this island with that of the adjoining part of the continent, and the relation which the elevation of the forest ridge of the weald valley bears to that supposed action. It is only necessary here to show the connexion between the acts of basining and denudation, and how their relation to each other is illustrated by the phenomena of both.

Since the explosion of the hypotheses of Werner and Hutton, it has been too much the fashion to ascribe all excavations and disruptions of strata to watery erosion only, either by violent and sudden irruption, or the more gradual operation of existing causes in river torrents, or meteoric action. Those geologists, therefore, who have speculated upon the union of the basins of the south of England, have supposed that the connecting parts were swept away simply by diluvian action, the basins having existed previously, as basins. Prepossessed with the notions of a basin, as the French geologists have described it, they have not perceived the connexion of the acts of basining and removal, nor formed any very decided opinion of the previous state of the beds removed by the catastrophe of denudation; and the evidence of their existence at that time in the horizontal position, if not wanting, has not yet been fairly brought into view.*

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* Geological Transactions, 1826, p. 128.

† Above and below the chalk are convenient terms, because, for this part of the world, the chalk is a convenient mark of division; but otherwise they only mean newer and older. And there is no other reason why the order of formations called tertiary, should date from this point.

It cannot be expected that this evidence should be of the most positive kind, and if it could have been collected in the hasty way that geological reviews are usually made, it would not have been to seek at this time of day. Fresh from the great convulsion here contemplated, the appearances of displacement and disruption would have been so plain as to admit of no hesitation; but the obliterations of ages have passed over them, and it is only by patient investigation; by the observation of one illustrative appearance here, and another there, as they are occasionally displayed; and by the combination of these *disjecta membra*, conducted with a unity of observation and research, that the geologist can make any progress towards a demonstrative and satisfactory conclusion.

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* When this was written, the author was only partially acquainted with the observations of Dr. Buckland, contained in his paper on "Vallies of Elevation," before alluded to, and published in the last volume of the Transactions of the Geological Society. The reader will there find many of the points, bearing upon this part of the theory of denudation, very clearly established.

*The strata which compose these basins, then, previously in a horizontal position suffered disruption; and in the act of basining, (whether by the elevation of the sides, or the subsidence of the central parts, is not now material,) all their parts were deeply and extensively fissured, in an order correspondent with that act;—producing, with the help of diluvian action, a system of longitudinal and transverse vallies answering to the double inclination (the dip and lateral bearings, or obliquity of the plane) of their fractured masses, and a consequent removal of the broken materials brought within the range of the denuding force.*

The effect of raising from the horizontal position, or in any other way stretching, a ponderous and frangible body, is to produce a division of its parts, in such order and direction as its varying strength and tenacity dictates; the fractured parts taking their places, according to their magnitude or gravity, or the disposition of those which support them. This irregular fracture, alternate elevation and subsidence, and settling of parts thus disturbed, are well exemplified in the familiar operation of the heaving of the spade in digging. If the earth be tenacious and the action steady, it tears with such a divergence of the principal rents as will be here described, and the more friable parts are seen dropping in, in such a way, and in such proportion, as the moving power dictates, and their structure allows. If another illustration were necessary, it might be found in what we observe in the elevation and cracking of the flour which covers the fermenting nucleus in a baker's trough.

Where opportunities occur for tracing these appearances in the weald, they are found to be in perfect accordance with this theory. These opportunities present themselves frequently in the clay districts, but they are more distinctly traceable in the stony, in the dip and variable lateral bearings of the several masses. It may be safely said, that undulation, at the time of deposit, had very little share in these phenomena, or in the construction of the hills and vallies of these districts. Every variation in dip or lateral bearing has its commencement in a fracture, or if the displacement be moderate, such a contortion as would be produced by the gravitation of bodies like these, moving under great superincumbent and lateral pressure.

The general dip of the chalk-hills is southward, but the lateral bearings of the several masses are variable,* and the inclination also different in different localities. Next to these succeed the more broken strata of the green-sand; and lastly, the smaller lacerations of the wealden formation; the widely spreading transverse fissures of which, concur to produce the effect of longitudinal ones over all the convexity of the "forest ridge." *(See Plate* II. *Fig.* 2.*)* But it is not to be understood, that there is any difference in the general disposition of all these parts. The convexity extends from the bottom of the English Channel to the bottom of what is called the London basin. This convexity may be likened to a dome, and the loss of a part of the crown of the dome is the weald vacuity. In other words, the commencement of each basin is in the anticlinal line of the weald valley. From this point, all the strata begin to slope. Both basins, therefore, may be said to be entire in a part of the wealden, although they have lost a part of their rims in the chalk and the glauconite.

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* In ordinary geological language, there is not sufficient precision used in these terms; and lateral bearings are confounded with the dip, which should express the backward and downward inclination only. Thus, of the strata in question, sometimes we are told that they dip S. E., sometimes S. W. The fact is, that they all *dip* to the south, generally speaking, but the obliquity of the plane, or *lateral bearing* of the different masses, is sometimes east and sometimes west.

The principal transverse fissures, some of which were destined to become river channels, have a remarkable correspondence on each side of the valley, particularly in the chalk, and in several instances are directly opposed to each other; which could not have happened without a simultaneous action and common consent, and continuity of parts. The direction of a rent would be ruled by the density and tenacity of the different parts of the stratum: occasionally deviating from the straight line, it might be lost in one part, and taken up and carried on by another, giving less resistance. The coincidence is therefore the more remarkable, and proves not only the continuity of the chalk strata at the moment of convulsion, but also their uniform density and strength. Of the vallies thus opposed to each other, by the continuity of the greater transverse fissures, the most remarkable are,—the defiles of the Arun in the South, and the Wey in the North Downs; the vale of Leatherhead, or the Mole, and that of Findon, or the Worthing road; of the Adur, and Smitham-bottom, or the pass of Merstham and Croydon. The Ouse is also opposed to the Darent, and the Cuckmere to the Medway.—(*See Map of Denudation, Plate* II.)

But it must not be supposed that this simple transverse fissure is the only appearance of displacement exhibited by the chalk strata. They have suffered, in common with the other rocky strata, that adjustment of parts which might be expected from the nature of the material on which they rest. If the fissile character of the stony strata determine their division in straight and broad lines, it would also be the character of the wealden formation to be torn and contorted in a manner widely different. For a stratum of clay of great thickness, carrying stone barely sufficient to give it stability, would tear rather than split in the act of displacement; and such a divergence of the fissures as might be expected in so tenacious a mass, can be readily traced in every part of the weald surface. This divergence and laceration has therefore modified the disposition of the stony strata still superincumbent upon the clay; and the subsidence, elevation, and contortion consequent thereon, are every where visible in the dip, and variable bearings of all their masses. In appreciating the evidence of these acts of laceration and fracture, it must not be forgotten also, that strata of various structure, far below these under review, have suffered the same disruption, and by the variable nature of their fracturings, have operated to modify, and in some cases, to obscure, a great part of the direct testimony of the order here described. The pressure of superincumbent strata of unknown thickness and kind, must also be taken into account; and it will not be thought wonderful, that, diluvian action, and the operation of more modern causes apart, there should be so little direct evidence of fissure upon the surface.

The divergence or distribution of the transverse fissures is to be traced in the upper stony strata, as well as in the minuter divisions of the clay districts. If a fissure of this sort be followed from its termination in any of the hilly countries, it will be found to present first a little coomb, into which the stone inclines on both sides, and at first carrying no water. By-and-bye, springs burst forth, (the natural consequence of this convergence of layers of stone,) and it becomes a valley with a rivulet; both the valley and the rivulet enlarge by the accession of other coombs and rivulets, the effects of the branches of one greater river fissure; and the eye of the observer may, from any considerable eminence, embrace the courses of these vallies, as they converge toward some of the river outlets.*

The simplest state in which these vallies of fissure exist, is that in which, after the rent was formed, the opening has been enlarged, at first by diluvian, and since by meteoric abrasion. Such, for the most part, are the great river outlets, through the chalk strata, and many of the water-courses through the other rocky beds.

The next in order, is that in which the rocks have dropped into rents beneath, as in the coombs above described, forming vallies of simple subsidence. These are to be found every where, where the tabular disposition is favourable to observation. The green-sand country from Warminghurst to Bedham-Hill, in this district, furnishes many picturesque examples of this modification of the fissure.

A third modification is that where the opening of a rent below has caused not only a similar displacement of the parts above, but has also brought down a portion of them, so that instead of a simple gaping of the strata, we see them perhaps on one side of the fissure leaning away from it, on the other dipping sharply into it. Carrying the investigation a little farther, the main body from whence the latter portions have been torn, will be found bearing away from the fissure, or perhaps remaining nearly horizontal. Evidence of these compound operations may be found in the chalk, and in the gullies which traverse the lower green-sand, in the western part of this district.

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* It will not be supposed that the author means that this should apply to the courses of all rivers, and in all their parts. He is now talking of the Arun and the Adur, and not of the greater rivers of the globe. But the principle is capable of extension to the tributary streams of these also; and all perennial rivers must have their sources in disruption,—for disruption and displacement are the essence of springs and fountains

In the pits at Houghton, West of the Arun, the chalk, besides the usual southward dip, has a lateral bearing westward, away from the river. In the eastern quarries at Stoke, the undisturbed chalk, or that which has not suffered by diluvian action, remains horizontal, or if it has a lateral bearing, it is eastward; a further proof of which may be obtained by examining the malm cliffs, by Amberly Castle, and along the meadows. This part of the river fissure is within the lower chalk, and yet between the sides there is an outlier of sand, intersected by the river, which must belong to the plastic clay formation, and could only have arrived there by subsidence into the rent at the moment of convulsion.

These fractures are sometimes found to terminate in notches of denudation, where, by the removal of the broken parts, the beds beneath are brought into view. An erosion of this sort exposes the galt far up in the malm at Bignor-mill; and the northern part of Petworth stands in a notch of the lower green-sand of the same kind. Another well-marked example of the joint operation of fracture and erosion, is to be found at Pulborough, where a coomb, carrying a small stream, extends from the escarpment of the ferruginous sand, through New-Place-farm, about three quarters of a mile, and terminates in a notch of the lower green-sand, a valley of weald clay at Bromer's-Hill, about a quarter of a mile in length.*

In following out this research in the wealden districts, the same phenomena are still visible, though rendered more obscure by the plasticity of the material, and by diluvian action. Wherever the stony courses have been opened, fractures, contortions, and variable dips are to be observed. Long and irregular rents pass transversely through them, and take up the streams, which, from the rarity of springs in this formation, are for the most part only winter ones, and convey them to the greater river outlets.

But the most complete evidence of the manner in which transverse fissure has operated to produce a valley, or series of vallies, is to be found in a history of the passage through this district of the

## RIVER ARUN,

which, rising upon the anticlinal line, or "forest ridge" of the weald excavation, and traversing that line a few miles westward,† turns to the south, and intersecting all the courses and formations above described, transversely, takes what is, in general, a direct, though extremely tortuous course, to the English Channel.

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* Another, with good examples of vallies of subsidence, subordinate, or branching off from it, may be traced from the hamlet of Nutbourne, through Bury Grove, and out at Crowell.

Every water-course intersecting the basseting edges of the strata, is in fact a notch or crack, enlarged by comminution and diluvian action—*the open extremity of a fissure.* This applies to the chalk, as well as to the minor formations; every river outlet is a crack in its basseting edge. If the angle of subsidence is acute, the fissure shows as a mere gap; if the stratum is more horizontal, and spreading over a wider surface, the fissure is a long valley, or succession of vallies.—(*See Diagram, Plate* II. *Fig.* 3.)

† It is not meant that the fissures upon the forest ridge, or anticlinal line, do not some-

In describing the most remarkable features of this course, it will be most convenient to follow the stream, from its entrance into the green-sand, to its termination; and afterwards go back with it from the green-sand, through so much of the wealden as belongs to the country here attempted to be described.

The river, where it enters the green-sand formation, is the boundary line between the parishes of Pulborough and Stopham, and is here enclosed in a defile about four or five hundred yards wide. On either side, the slope of this defile is gradual, but soon rises on the east to the elevation of two hundred, and on the west of four or five hundred feet. Proceeding southward, the banks become more precipitous, and the valley narrower, and before the river issues from the green-sand to enter the ferruginous, its alluvium is little more than one hundred yards in breadth.

Within the latter sand, the course of the river is again a little more free, but for the distance of half a mile, the banks have still the character of a ravine, rising on either side precipitously to the height for the most part of two or three hundred feet.

In examining the course of the river through this part of the Shanklin sands, it will be found that the character of a fissure is most apparent on the eastern side, where the greater compactness of the materials seems to have preserved them from comminution and erosion. Near

times take a longitudinal direction. The town of Horsham stands in one of these, enlarged by diluvian action. The series which breaks off at Dane-Hill, is resumed in the high grounds of Rusper. The Arun takes its course along this valley.

the verge of the gorge, large masses are found sloping towards the river; and farther back, the entire bed drops at a very acute angle, and is now quarried near the spot at which it is disjointed from the main body. The whole slope of this side of the gorge, is formed by the dropping down of a large angle of the stone, from the loss of its support; but for which circumstance, it would have advanced many hundred yards in the north-east angle of the opening.*

Farther down, all the parts of the eastern side that are visible, are in the usual position; having a lateral bearing eastward, as seen in Stopham lane, near the bridge.

The western side of the defile does not correspond much with the eastern, except where the most compact beds of green-sand are opposed to each other. There is a more gradual recession of the ground, although immediately behind, and a little in advance, it rises rapidly to double the height in Bedham-Hill; in which is begun the high range of hills of the lower green-sand, which is carried round all the upper end of the weald vacuity.

It has been before observed, and it is worthy of remark, that the composition and texture of the green-sand beds, are materially altered west of the river. A brittle and cherty stone succeeds to the compact argillaceous stone of Pulborough, and so is continued with little interruption round to Leith-Hill, on the Surry side of the range.

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* A similar disposition is to be observed at the entrance of the defile which carries the stream that runs into the Rother, between Petworth and Byworth. In the quarries in the Rectory-grounds, the stone may be observed sloping rapidly easterly, or down toward the stream, and the fractures answering to this inflexion have been disclosed at the top of the hill, under and about the Rectory-house.

The rapid rise of these eminences is still more worthy of observation. Two causes combine to produce this effect—the gradual, though slightly, increasing elevation of the strata above the level of the sea, from east to west, and their increasing consequence, as they have been better preserved from removal, in the western part of the great valley. Every advance toward the centre of the weald, of any of the upper strata, is answered by a corresponding increase of height in their hills, commensurate, in great part, with the prevailing angle of inclination. The highest chalk-hills are those which advance farthest forward in the range; and the same order, with some deviations, is observed of all the rest. The Shanklin sands, which are mere hummocks under the Downs at Wiston, rise into considerable hills as they swell out northward, in the vicinity of West-Chiltington and Pulborough. Another great advance at Bedham-Hill raises the spectator within view of a considerable expanse of sea-coast beyond the Downs about Arundel; and the hill countries of Haslemere, Godalmin, Hascomb, and Leith-Hill, mark the preservation and continuity of the Shanklin sands over the central ridge, or anticlinal line, of the weald.

The only other circumstance worthy of notice in this, the most picturesque part of the Arun, is the depth of its channel, which exceeds that of any other part of the stream, except in the marsh above Amberly.

In whatever way the river's course was produced, it is not extraordinary that this should be the case. The banks were doubtless at first deep and precipitous, and the natural operations which succeeded the catastrophe that made it, would tend to keep them so. In times of flood, an immense body of water is here contracted in a narrow space, and although the fall is trifling, the friction is sufficient to carry away whatever drift the stream may bring with it, within the bed of the river. Whilst accumulation is constantly going on upon the borders, by entanglement in the herbage, and the other phenomena of alluvial growth, a certain space of water-way must be maintained; and, if the banks accumulate, an equivalent will be found in the depth or the width of the channel.

Leaving the defile above described, at Stopham, the Arun receives the Rother, which, rising at the foot of the Hampshire chalk-hills, takes a course through a series of longitudinal vallies, to unite with it; and being opposed in their direct course southward by the outlying galt of Hardham, they turn to the east, and run round by Pulborough and Wiggonholt. The course of the united streams, is here through a broad expanse of alluvium, apparently based upon galt; for, besides that galt clay is produced from every deep section about the river, between Stopham and Houghton, outliers of that stratum are found rising from under the alluvium, on both sides, in several places. Nor are other evidences wanting of fissure, and of subsidence, in this part of the river-course. The longitudinal valley in which the Arun receives the Rother, and which carries the united rivers round by Pulborough, is marked on the north by a sudden dip into it, extending from Fittleworth to Chiltington Common. This is particularly visible at the turnpike-gate at Stopham,* and in

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* The disruption and subsidence is visible by the road-side, within a few yards of the gate, and the galt is seen emerging from under the diluvium upon which Stopham-House is situate. The longitudinal valley in which the Rother here takes its course, and in which it is united with the Arun, is one of subsidence, apparently connected with the fissure of

Pulborough-church hollow; and, on the south side, at the blacksmith's shop at Cold-Waltham, from whence the galt extends through the peninsula of Hardham. At the latter place it drops in toward the river, at an angle of 20 or 30 degrees.

Passing the remainder of the galt,—where the river enters the malm, bold cliffs of thirty or forty feet stand out on either side, having nearly half a mile of alluvium between them.

Here the malm, with its beds of green-sand, are in direct opposition on each side, but lowest on the east. And in the rocks about Bury, the same lateral bearing westward is to be observed, that is seen on the same side of the river in Houghton chalk-pits.

The chalk-gorge, as might be expected, furnishes a fine example of fissure, enlarged and modified by erosion. It has been observed, that a visible backward bearing of the rocks on each side, was not a necessary part of the evidence of fissure, because in the propagation of a rent upwards through strata of various texture and tenacity, much irregularity would ensue in their disposition; but here there is direct testimony of divergence; and the enlargement of the opening by diluvian action, is indicated by the gradual slope on either side.*

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Jacquet's-Hill, and the Vale of Greenhurst (to be afterwards described), and is a continuation of the green-sand basin or trough there noticed, the apex of which is Warminghurst. The outlying masses of galt of Wiggonholt, Hardham, and Tripp-Hill, are all in the line of this subsidence, and carry on the marks of the disruption towards Duncton-Hill.

* At the top of Houghton-Hill, a curious phenomenon may be observed, illustrative of the chalk fissure. The valley called Fair-mile-bottom, running south-west and north-east, is opposed to another, branching off from the river valley at Stoke, and forming a deep coomb below the gate-way of Arundel Park. These two depressions are separated by the eminence upon which the gateway stands, along which the road is carried; and which connecting

To complete this sketch of the course of the river through the country under review, it is necessary to return to the defile of the lower green-sand, and follow up the stream, into what is called the forest range,* or as much of the wealden as is included in the Map.

In taking a general view of this part of the river-course, it is strikingly obvious, that the stream has been employed in filling up, and not in excavating, the valley in which it runs.† This valley here intersects several considerable eminences of the weald clay, and is bounded by gentle

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the Bury and Arundel Hills, is a miniature representation of the *col* of Alpine countries. When carriages run along the part of the road about the centre of the *col*, a remarkable rumbling is heard, plainly indicative of the cavernous state of the chalk below. A little longer continuance, or more forcible action of the denuding flood, would have swept away the remaining part of the fissure, and laid the two vallies into one.

* Heretofore the "Hastings sand," or "iron-sand."

† It is extraordinary that some naturalists still advocate the doctrine of the excavation of vallies and river-courses by the abrasion of their own waters, and the constant operation of existing causes. This error is not confined to closet-speculators, but has also infected the reasonings of men of extensive observation, misled by what they see effected by these operations in mountainous countries. But these causes not only will not apply to the peaceful streams of more level districts, but are also entirely inadequate to the effects ascribed to them, though operating (as we know they have not done without interruption) through all time.

Living in a mountainous country, and witnesses of the excavating powers of mountain torrents, Playfair and Hutton made this a part, and it was the weakest, of their theory. And it is wonderful that, demonstrating, as they do, the successive elevation and depression of the earth's surface, each of which must have been attended by a deluge, they should have appealed from such giant powers, by which the minor operations of channeling and excavation are sufficiently explained, to the unnecessary pigmy forces of atmospheric action, and other natural and existing causes.—It is "Ossa to a wart"—"a bucket of water upon Plinlimmon" to the "great ocean!"

undulations, with here and there precipitous banks, which are not always opposed to each other. It has also on both sides very extensive diluvial deposits, which, with its alluvial meadows, give it lands of agricultural character, far superior to that of the country generally. In these diluvial masses, angular fragments of chert are found in great abundance, some chalk-flints, and all the materials of the superior strata, mixed up with those proper to the wealden formation.

Below Wisborough-Green, the rivers receive a considerable branch, which skirts round from Kirdford, and drains a great part of the country between Petworth and the anticlinal line of the nucleus of the weald. A little above Wisborough-Green, this branch receives a stream which traverses a well-marked member of the longitudinal fissuring,* a ravine which divides Dunhurst and Barkfold lands, and where the stony strata are found to have lost much of their southerly dip, and become horizontal as they approach the apex of the forest ridge. It would exceed the limits prescribed to this research, to pursue the course of the Arun farther. But to render the foregoing sketch more subservient to the object in view, it must be stated, that the transverse fissure which is the foundation of this river-course, after being thus distributed upon the central ridge of the weald, is resumed upon the north side of it, and becomes the channel of the Shalford Brook, which empties itself into the Wey, and traverses the chalk at Guildford, in a direct line with the Arundel outlet.

It is impossible to view the structure of this outlet, and the evidences every where of disturbance and convulsion, without speculating upon their mode of operation. That a river-course should pass in a direct line through fifteen or twenty miles of a mountainous and rocky country, in direct opposition to the natural disposition of the strata, was a phenomenon, though much surpassed in countries of grander features, too remarkable not to have attracted very early the attention of the writer, and given it more interest with him than any other question of local geology.

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* The divergence of the transverse fissure.—(*See Plate* II. *Fig.* 2.)

That the weald vacuity would have been a lake, but for these gullies, is sufficiently evident; but that it has ever been so, is by no means probable, from any thing that can be observed at present. The hypothesis which supposes it to have been a lake subsequently to the great catastrophe which hollowed it out, also supposes these outlets to have been the operation of watery erosion, the friction of their own streams, or the debàcle of the lake itself. That this could not have been the case, is proved by the existence of more than one of them. The first that gave way would render all the rest unnecessary and impossible, and if every drain had had its separate pool, the water would never have risen high enough in either of them separately to force a passage through so many obstacles.

If, on the other hand, it be proved that these masses are deeply fissured, it is also proved that they have been in motion. And the formation of such a channel as here described, in a direct line through such heterogeneous materials, must have been the result of a simultaneous movement of the whole, let the moving power be what it might. That this operation was coeval with the catastrophe which left the material features of this part of the world such as we see them, is apparent from a collective view of the concomitant phenomena. And whether the Sussex and Surry hills, with their accompanying strata, were severed by the disruption and dispersion of the intervening parts, or simply by the sliding down of the whole mass, which is much less probable, or the joint effect of these causes, the slightest inclination or obliquity of the basis upon which it must be supposed to rest, would be sufficient to open the fissures in the direction in which we see them.*

The next most remarkable transverse fissure that can be plainly traced through the chalk of this district, and its subordinate strata, is the defile by which the Worthing road traverses the south Downs by Findon. It is opposed to the Valley of the Mole in the north Downs, but it carries no water till it issues from the Shanklin sands, at Ashington Malt-House.

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* The gradually increasing dip from the Alton Hills eastward, has been touched upon by Mr. Murchison, (*Geological Transactions*, 1826.) "The beds dip every where towards the chalk, but in the south-eastern part of the district, more rapidly than in the north-western. They are inclined towards the Alton chalk-hills, at an angle which is scarcely perceptible, and accordingly in that quarter are expanded over a more considerable extent of surface, than towards the south Downs, where the dip frequently amounts to ten or fifteen degrees." This general inclination increases still more in this district, which will be seen by a comparison of the chalk at Stoke, when viewed from the road above Houghton-bridge; and that in Beeding-Hill, as seen from the road leading from Steyning to Henfield; and again in the malm-rock at Fulking and Poynings.

It is obvious that every change of dip and inclination, or lateral bearing, must be attended with fissure, or the contortion which is made up of a series of minute fractures. Thus, if the inclination have increased from ten to fifteen degrees in any given distance, fractures commensurate with that increase must somewhere exist.

About and below Findon, great quantities of chalk-flints have been washed into it, so as to give it the appearance of a river-bed, or the course of some ancient torrent.*

No satisfactory longitudinal sections have been made in the chalk, to determine the lateral bearings on each side; but a westerly bearing (away from the fissure) is observable in the stone quarry behind Ashington Malt-House. This rent divides the chalk between the Arundel and Shoreham outlets into two great masses, as those of Piecomb and Saddlescomb do that between the Adur and the Ouse.

The Adur, or Shoreham fissure, is very quickly distributed, and by one of its larger branches gives a river to this district called the Bines. The channel of this little river traverses all the courses of the wealden obliquely, and is subdivided and lost in the coombs of the forest ridge, or anticlinal line between Billingshurst and Horsham.

The Shoreham fissure is very nearly opposed to the depression in the north Downs between Croydon and Reigate, called Smitham-bottom; which exhibits so strong an illustration of the action of transverse fissure, that, although a little foreign to the immediate subject of this memoir, it cannot be passed by without notice.

The fracture which was the origin of Smitham-bottom, cuts through the Shanklin sand, between Red-Hill and Redstone, upon the Brighton road, giving transmission to a branch of the Mole which rises at Merstham. At this place, besides giving exit to the stream, it cuts off the basseting angle of the Nutfield fuller's-earth beds, which thin out upon Red-Hill, on the opposite side of the ravine.—*(See Section.)*

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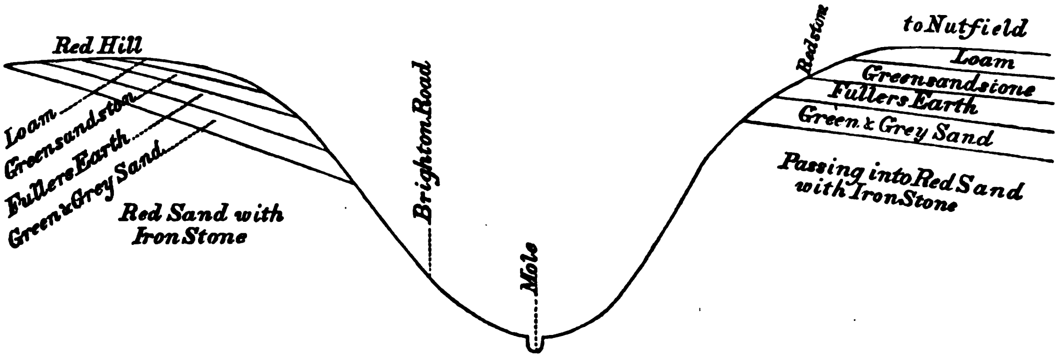
* The comminuted chalk at the upper or northern end of this disruption has been well exposed lately, in some deep cuts made to widen and improve the road.

Supposing the non-existence of this part of the fissure, and the stream left to its natural operation, it will be manifest to an observer, who takes his stand upon any of these eminences, that its course would be along the vale at the foot of the chalk-hills, and out at Reigate Heath.



## VALE OF GREENHURST.

The foregoing observations have been chiefly confined to the illustration of the transverse fractures, and the manner in which, by their distribution into each other, and over all the parts of the dome of the weald, they are made to answer to the elevation of its strata, or, what is tantamount to that elevation, the depression of the adjacent parts of the same strata, to form the basins of London and Hampshire, or more properly of the English Channel.

It remains to prove, that the act of lateral subsidence, or central elevation, also produced, as might be expected, occasional longitudinal fissures, determined by that irregularity in the act of subsidence, or in the texture and position of the parts themselves, before spoken of; and modified or directed by the partial subsidence, or elevation of the underlying strata. The longitudinal vallies formed by the basseting edges of all the several strata, are too obvious to escape notice. Wherever a stony stratum breaks off, an escarpment is formed, between which, and the talus of the formation below, a valley necessarily exists, though often obscured by diluvial and alluvial matter, and crossed by vallies of erosion, or of fracture enlarged by diluvian action. But besides these depressions, one longitudinal valley of a very peculiar construction exists in this district, strongly illustrative of the manner in which cross fracturings have operated, to produce that comminution of the materials which once filled the weald vacuity, and which prepared them for removal.

The road from Storrington to Thakeham crosses the small but deep valley of Greenhurst, the north side of which is formed by a steep acclivity called Jacquet's-Hill, and the south by a less considerable eminence called Mary-Hill. The first is found to be composed of lower green-sand, with blue lime-stone courses, and lenticular masses, dipping northward at an angle of 20° or 30°, and the latter of the corresponding layers dipping southward at an angle more acute, and with much appearance of fracture and disturbance. The opening thus formed is about 100 feet in depth, and three furlongs in width, and is bottomed by weald clay, which also forms half of the acclivities on each side.

Passing over the ridge of Jacquet's-Hill, and through a depression of half a quarter of a mile, filled with detritus and alluvial soil, the same green-sand strata are again found in their more usual position, rising north, into the village of Thakeham.

Tracing the ridge of Jacquet's-Hill, the retroverted mass of green-sand strata, eastward, it is found to terminate, at the distance of a mile or more, in the eminence upon which stands Warminghurst Church. This eminence, which may be called the butt-end of the ridge, is about 150 feet above the valley of weald clay, which at this extremity is half a mile in width. From Jacquet's-Hill, westward, the ridge soon enters the ferruginous sand, under which, after a course of two miles more, it is lost; but not till after it has exhibited, about the hamlet of Hurston and Hurston-Mill, much disturbance and comminution within its own body. In all this course from Warminghurst to Hurston-Mill, it preserves a straight unvaried line, and bold escarpment; gradually approximating to the corresponding eminence of Mary-Hill, till they unite, or are both together lost under the ferruginous sand.

The strata of Mary-Hill, which remain as a part of the main body, in situ, dipping toward the chalk, spread wider, and through two or three fractures, admit some considerable streamlets at Fryern and Wantley; and are lost, as said above, near Parham Park. But although the green-sand is here lost, a continuation of the rent can be traced westward, by the heaving of the ferruginous sand; and in Parham Park,* and at Sparright, it is discovered dipping northward, and exhibiting a stratum of nodular masses of a ferruginous concrete of univalve and bivalve shells, which belongs to the middle part of the ferruginous sand, and is found cropping out about two miles north, in the natural or more usual position, at Pulborough.

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* The woody knolls of Parham Park and Wiggonholt, are heaved up so as to be above the galt of the latter place, with which they would have formed a clay trough if the galt had remained upon them. The dip of this galt outlier, as well as that at Pulborough, is such, that, being continued on southward with the same degree of inclination, they must pass many

Returning to the eastern extremity of the ridge of Jacquet's-Hill, and viewing it in its relation with the main body at Thakeham, with which it lies at an obtuse angle, it will be observed, that it forms the southern side of a triangular basin or trough of green-sand, the apex of which is Warminghurst-Hill, and the base, an imaginary line drawn from West Chiltington to Parham; presenting in miniature an exact resemblance to the chalk-basin of London; being bounded on both sides by green-sand, dipping in opposite directions, and having its contents also of a nature different from its component parts. Carrying on the parallel a little further, the clay valley of Greenhurst may represent the weald denudation, bounded on one side by the perfect basin above described, and on the other by the green-sand range of Mary-Hill, representing the half basin of the south Downs.*

The ridge of Jacquet's-Hill on the north side of the fissure, breaks off as before described, at Warminghurst, but is resumed about three miles

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hundred feet below their kindred parts at the chalk-hills. The proof of consentaneous elevation and subsidence is complete. The same chain of actions is to be traced onwards in the relative position of the sands of Waltham and Horncroft; and the galt of Hardham and Tripp-Hill.—*(See the foregoing note, p. 57.)*

* Instead of this "valley of elevation," it is plain there would have been what is called a saddle, if the rocks had been heaved merely, and not disjointed. They must exist in that position after they are lost under the ferruginous sand.

eastward, in the outliers of Ashurst. These outliers consist of green-sand masses, insulated upon the clay, and having a northerly dip like Jacquet's-Hill, and the high grounds of Henfield, from which they are disjoined by the alluvium of the Adur. The line is then continued on by Henfield-Hill, in a south-easterly direction, through Woodmancote, pointing toward Poynings, and is lost in the lands of Nutknowl and Holmbush, where it meets with the galt of Newtimber. At Henfield the ferruginous sand has been retained, and the whole ridge to Woodmancote consists of both members of the Shanklin sand. This ridge of retroverted Shanklin sand is met, as at Hurston, or Jacquet's-Hill, by a corresponding one on the north, with the usual dip toward the chalk-hills, running from behind Henfield, on through Blackstone and Alborn to Hurstperpoint; and forming another miniature basin of green-sand, containing ferruginous sand like that at Thakeham and West Chiltington.

Returning to Greenhurst, and tracing the opposite or anticlinal side of the fissure, from Mary-Hill eastward; it takes its course by Ashington Malt-House, across the Worthing road to Chancton, and from thence by Wiston to Wappingthorn and Huddlestone, as before mentioned, where it is opposed to the outliers of Ashurst. Crossing the Adur, it is found again in the lands of New-Hall, and can be traced, although much obscured by the overlying galt,* north of Edburton and Fulking, to New-House, where it approximates to the opposite or Henfield line, and is lost, with it, under the galt of Poynings and Newtimber.

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* The immersion of the Shanklin sands is so great at this part of the southern side of the valley, that they might be supposed to be nearly lost, or to have thinned out, if it had not been for the retroverted masses at Henfield, which exhibit the greater part of the ordinary thickness of these beds. The much increased dip of all the strata, the chalk included, tends also to assist in producing this obscuration.

The weald clay valley, bounded by these anticlinal masses of the Shanklin sand, gradually expands from Greenhurst, eastward, and at Ashington opens into the greater expansion of wealden on the north, by the removal of the connecting parts between Warminghurst and Ashurst. It is again contracted by the outliers of the latter place, and then stretches up eastward, between Henfield and New-Hall, toward Poynings, including Broodmere and Horeham Commons, and all the clay lands between the sands of Truely, Edburton, and Fulking, on the south, and Woodmancote and Holmbush, on the north.

The valley of weald clay ceases near Poynings, and the rent, for it cannot be considered in any other light than as a longitudinal fissure, cannot be traced any farther in the subjacent strata; but in the chalk above, it divides into two branches, and forms the depressions of Piecomb and Saddlescomb. A crevice from the latter is the well-known fosse of the Devil's Dyke; which is a good specimen of the manner in which a rent may be enlarged by diluvian and meteoric action. Minor examples of the same kind, may be seen at West Burton-Hill, between Stoke and Rackham, and in other parts of the South Downs.

The western part of the fissure, or the proper Vale of Greenhurst, carries no water till broken into by some streams from the malm upon the south. The eastern, or that part of it which lies on the other side of the Adur, contains a considerable stream, also derived from the malm at Fulking and Poynings.

Taking a general view of this curious disruption, it affords a strong illustration of the manner in which the weald has been denuded of its upper coverings. If the gap at Piecomb, running out through the chalk at Brighton, be taken into account, its extent is not less than from 20 to 25 miles. But exclusive of its operation upon the South Downs, it can be distinctly traced through fifteen miles of country, intersecting the transverse fissures of Shoreham and Findon, and approaching very near, if not actually intruding into that of the Arun. The effect of the cross fracture is visible, in the removal of the parts which connected the outliers of Ashurst with the main body at Warminghurst; which, with the insulation of all the remaining parts of the north side of the valley, shows that they all narrowly escaped destruction when the act of removal was going on.*

That this is not an isolated phenomenon, and unconnected with the great act of subsidence or elevation, which it is the object of the present Essay to prove, will be apparent to any one who attentively studies the inflexions and distortions of all the other parts of the weald;† and that it resembles many other effects of that act, is proved also by the opening into the greater clay expansion, between Warminghurst and Ashurst; which exhibits all the ordinary appearances of the great valley. Supposing the remainder of the insulated Shanklin sand, which constitutes the northern boundary, to be removed, the same surface would be exhibited; and the country from the Arun to Poynings would be weald clay, the Shanklin sands breaking off abruptly at Bedham-Hill, as they do at Leith-Hill, on the opposite side of the weald.

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* The greater recession of the chalk southward between the salient angles of Duncton-Hill and Wolfstonbury, cannot but be connected with this disruption. And the obscuration, and almost entire immersion, of the Shanklin sands between Steyning and Wappingthorn, and between Edburton and Henfield, are curiously illustrative of the operation.

† Displacement and dip, contrary to the general order, is said sometimes to occur, and to be "produced by local causes." What are these local causes? There is no displacement, fault, subsidence, or elevation, that cannot be resolved into the great operation of basining, and concomitant act of denudation. When a coal seam is exhausted, the pillars left to support the roof of the mine are successively worked away by the retreating miners, and the

Besides the vallies above described, there are longitudinal ones, also the effect of irregular subsidence, and in which waters sometimes take their courses. But most of the longitudinal vallies are vallies of erosion.* Such are the depressions, or series of depressions, below the escarpments of each of the stony strata. These escarpments are fre-

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roof let down; without the buildings or the inhabitants upon the surface being sensible of the change—the rocks are said to "settle it amongst themselves." Just what happens here in the small way, occurs in the large, in the operation under review, but with this difference;—the displacement has been too great for the effect not to be traced every where upon the surface.

* A good specimen of the longitudinal valley of erosion is exhibited on the left of the Arun, immediately above the green-sand gorge. The two eminences of Toat-Hill and Pithingdene-Hill (or Oakhouse-Hill), the former denuded, the latter still capped by fractured green-sand stone, are divided by a deep valley called Under Lee, in which the upper bed of weald clay is cut through, and the first course of Hastings sand exposed in the bottom near Pickhurst. So that Toat-Hill is in part an outlier, or a semi-insulated portion of the uppermost bed of clay.—(*See Section, Plate* I. *Fig.* 3.)

The study of this phenomenon, upon the spot, in relation with the river-course, and with the form and bearings of the neighbouring vallies and eminences, is most interestingly illustrative of the operation of diluvian action upon river fissures.

quently cut through by vallies crossing them at right angles, some of which may be reckoned vallies of erosion only, or, having perhaps begun by fissure, have been so enlarged by watery action, as to have lost all vestige of their origin, except their transverse direction.

It is unnecessary to dwell upon the mode of operation, and the share that the last-mentioned agency has had in modifying, and sometimes entirely obliterating the appearances of fissure and disruption. The enlargement of the river crevices, and the rounding off of the angles of fracture, the scooping out of the clay, the filling up of gullies, and the entire removal of broken masses, are consequences sufficiently obvious. To the eye of the practised observer, the weald valley presents the appearance of a great water-channel, after a flood:—some parts of it clean and clear from all encumbrance, others loaded with drift; the banks in some parts torn clean away, in others heaped up with rubbish.*

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* The general reader may probably not be aware that our present seas have had no concern in these changes, nor in the excavations of their own beds. They flow in the low places left by the last great cataclysm, and date from that period, without change beyond what is produced by a trifling friction upon their borders. The convulsion here referred to, and not the sea which flows through it, opened the straits of Dover, and severed Great Britain from the continent.

It may be worth while also here to remind the reader, that in the contemplation of these phenomena, he must revert to the original, or at least prior state, and most probable position, of this part of the world, leaving out of view for a time its present form; or, to speak perhaps more intelligibly, the question is not how it has been operated upon as it is, but as it can be restored in the imagination. Thus, in the estimation of a ruined building, we take into account the state in which it existed before the change came upon it; and think of, the forces by which that change was effected, not as they would operate upon the dilapidated, but upon the perfect edifice.

The act of denudation, also, as it is called, must not be supposed to be confined to the valley here treated of, nor to the beds below the chalk. The same convulsion bared the chalk-hills, and swept away or broke up much of the contents of the basins themselves. The chalk-hills are in fact only denuded and basseting edges of a stratum of great thickness, which is thus in the same predicament as the other formations, above and below it;—breaking off more or less abruptly where it has been moved out of the horizontal line, at an angle more or less acute, as in the general range of the Surry hills, or in the Hog's-back, near Guildford; and continued over a broader expanse, as in Salisbury or Marlborough Downs, or the plains of Picardy and Champagne, where it has suffered less violence, and remains in a line of more perfect parallelism with the horizon, and with the strata beneath.

Accidents in the history of the chalk, so obvious as these, could not have escaped notice, but from the long habit of considering a chalk-basin as something *sui generis*, of independent existence, and the area of deposit;—a fallacy set up by the French geologists, and continued by a too ready acquiescence in their powerful example.

# CONCLUDING OBSERVATIONS.

THE distrust of every thing that bears the name of theory, engendered by the failure of the principal general hypotheses of geology, has been carried to the opposite extreme of scepticism, even with respect to the theories of partial phenomena, when borne out by a train of demonstrative facts. If geology has emancipated itself from the tyranny of systems, and from faith in Neptunian and Plutonic theories, there is no reason why it should make itself a mere registry of facts, and be given over to a spirit of minute observation, which dwells upon detail, till it has no longer the power to look abroad, and take comprehensive views of what is passing around it. It has been well observed, by one of the warmest and best geologians of his own, or of any time, that, " though a man may begin to observe, without any hypothesis, he cannot continue long without seeing some general conclusions arise; and to this nascent theory it is his business to attend, because, by seeking either to verify or to disprove it, he is led to new experiments, or new observations."*

The truth of this remark is apparent, in the conjectures which are constantly hazarded by the most cautious recorders of facts; who, in the very act of observation, pass by circumstances, of which some preconceived notion does not allow them to see the existence; or couple what they observe, with circumstances with which they have no relation; and who, whatever they may profess, are constrained to be hypothetical in every step they take.

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* Playfair's Illustration of Hutton.

In this way the French naturalists have reasoned upon the contents of their chalk-basin, as if it had been in existence anterior to the æra of those deposits. And although they have not ventured upon an explanation of the manner in which they suppose the basin to have been formed, it is evident that they have carried on their researches under that impression.

In their description of the Paris basin, they say:—"On peut donc se représenter que les materiaux qui composent le bassin de Paris, dans le sens où nous le limitons, ont été déposés dans un vaste espace creux, dans une espèce de golfe dont les côtes étoient de craie.

"Ce golfe faisoit peut-être un cercle entier, une espèce de grand lac; mais nous ne pouvons pas le savoir, attendu que ses bords, du côté sud-ouest ont été recouverts, ainsi que les materiaux qu'ils contenoient, par le grand plateau sableux dont nous avons parlé d'abord."*

In various other parts of the description of the environs of Paris, allusions are made to the lake or gulf-like conformation of this basin, or continent cavity.

"Une disposition assez remarquable tend à prouver que le terrain qui vient d'être décrit est en effet le bord d'une espèce de bassin ou de golfe; ce sont les cailloux roulés souvent réunis en poudinques très durs, qu'on remarque sur plusieurs points de ce rebord, comme on les trouve sur les grêves des golfes encore occupés par la mer." *

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* Descrip. Geol. des Envir. de Paris, 1822, p. 7.

It is evident, therefore, that theoretical notions of the existence of the basin, as the area of a lake or inland sea, have regulated the speculations, if not governed the researches, of these naturalists. And what are the suppositions of the alternate flux and reflux of sea, and of fresh water into this basin, but a sequence of this line of reasoning?†

That a depression in the chalk sufficient to contain all the mass of tertiary formations of the Paris basin, existed previous to their deposit, is not perhaps impossible, but the probability must rest upon other grounds than those already stated. That the chalk underlies these tertiary formations in all parts of the basin, is admitted, and proved by the projection of some parts of it through them; although it is sometimes spoken of as a zone, or border of the supposed inlet, like the beach (grêve) of a modern sea. A tranquil deposit, either mechanical or chemical, such as chalk is supposed to be, or such as the glauconite below it, cannot be supposed to have been made in any other than in

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* Descrip. Geol. des Envir. de Paris, 1822, p. 7.

† "Les deux ceintures qui bordent ces bassins (d'Angleterre) n'étant point continues, mais comme ouvertes du côté de la mer, leur donnent à l'un et à l'autre, et notamment à celui de Londres, la forme d'un golfe plutôt que celle d'un lac. Les cartes comparées rendent cette disposition et ces analogies de géographie physique très-frappantes."—*Ibid*, p. 184.

The difficulty of considering countries washed by modern seas apart from them, and from their present relations, is sufficiently evident in this passage. Whether the parts necessary to complete the boundaries of the English basins exist or not, is problematical; and if they do not, it is evident that, except in reference to our present seas at a higher level, they bear no relation to gulfs or inlets;—a supposition involving too many difficulties in every way.

a horizontal position; and in that state the strata do not afford thickness for such a scooping out as must be supposed, if it be meant to explain the construction of a basin in that way. And if the parallel of the French and English basins holds good in their structure, as it does in what regards their contents; and it be proved that the basins themselves are coeval with denuded cavities, and their formation the chief cause of the latter phenomena, they cannot have been the area of deposit, either as lake, gulf, or inland sea. Of the English basins it may be safely asserted,—that, being fissured in all their parts in the act of subsidence, and many parts of them of higher level than the intervening excavations, *no deposit could have taken place within them, which did not fill denuded cavities.** The contemporiety of these acts being established, it follows of course, that the chalk, with all its superincumbent strata, existed previously in a horizontal position.

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* At the risk of being accused of "travelling out of the record," the conjecture may be hazarded, that the recent threatened failure of the "Thames Tunnel," was occasioned by the disturbance which exists in the mineral strata, along the greater part of the bed of the Thames. Although there must be a series of rents and subsidences along the bottom of the London basin, it does not follow, that the course of the river should be always exactly within their axis; so that a Tunnel through the London clay, in those parts where the river has been directed over it, in an unsubsided, or undisturbed state, is perfectly practicable. But where rent and subsidence, or what are commonly called *faults* have taken place, there remains nothing but loose diluvial and alluvial soil, through which it must be at all times dangerous to venture.

If, therefore, the expedients for repairing the mischief fail in this instance, a spot might still be chosen where the river takes its course over the clay, that has not been disturbed by the convulsion which basined the chalk.

It is not meant to be inferred, that because the chalk was horizontal, there were no inequalities upon its surface, or that it had not suffered from disturbing causes, anterior to the æra of the higher deposits, and to the assumption of the basin shape: conglomerates of chalk-flint, and other phenomena of watery action and abrasion, are sufficient proofs to the contrary. All that is here implied, is, that the acts of basining and of denudation were contemporaneous, and stand in the relation of cause and consequence.

Nor must it be supposed, that the phenomena of fissure and disruption, produced by the formation of the two basins, ceased with the weald denudation. Although the comminution of their strata was not sufficient to produce their removal, beyond the Alton-Hills, the same actions have been continued onward in a range of vallies, which it is not necessary for the present purpose to explore, as far as the basins extend.*

To recapitulate the sum of the above review:—The disruption of the chalk strata by the elevation of the central parts, or, what is tantamount to that action, the depression of the lateral across a fixed point, or fulcrum, produced the two basins, and opened the weald to the denuding flood. A system of longitudinal and transverse fissures, corresponding to these actions, is to be traced in the disposition of the hills, vallies, and water-courses, and of the ground generally, in the chalk itself, and from the chalk downwards to the bottom of the denudation; or, in other words, to the top of the anticlinal line, or nucleus of the weald.

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* As this sketch has only reference to the basins, as they relate to the weald denudation, nothing is said about the probable existence or non-existence of the other side, or south-eastern part of the Hampshire basin.

The mind of the reader will also revert to the remarkable phenomena of displacement and convulsion exhibited in the Isles of Wight and Purbeck, and other parts of the coast,—matters properly belonging to an enlarged history of chalk-basins.

These appearances, together with those of erosion, the deposit of diluvium, and the general arrangement of parts, prove the cotemporiety of the acts of basining and denudation; and that anterior to those acts, all the strata had existed in a horizontal position; consequently, that no deposit could have been made in basins that did not fill denuded spaces; and that what are called tertiary formations, were deposited before the basins were in existence. A wide field is thus opened, not for conjecture, but for research. And if the subject of derangement be cultivated with the same fidelity of observation, as has been of late that of structure, results cannot fail of being produced, destructive of many errors, and corrective of many received opinions.

The disclosure of what are called fresh-water formations, below the chalk, is proof, that although that stratum may be used as a convenient line of demarcation, it cannot be considered in a light different from the marine deposits which alternate with the terrene above it, or that it does not form a part of the same suite. *

The theory of fresh-water formation, appears to rest upon a

---

* The existence of the remains of some of the higher orders of animals in the Stonesfield-slate, is proof of the doubtful state in which the theory stands, that assigns them to the tertiary strata only, and makes the chalk for this part of the world, the boundary of division between these strata and what are called the secondary.

better foundation than peculiar mineralogical character, or a limited extent of surface:—nevertheless, it cannot be supposed, but that it was first suggested, or at least very much favoured, by the supposed existence of a continent cavity, or basin, the area of an inlet or lake.*

Although it be proved, that the basins of London and Paris are of an æra posterior to their contents, and therefore could not have been the areas of deposit, it does not follow that the strata they contain were not the creations of different agencies, and the habitations of a different race of animals. There is no reason why these basins, or rather the formations of which they are composed, should not have been continuous surfaces of the same area, successively the beds of seas and of fresh-water marshes; but we know too little of the then-existing state of the world, to be able to talk of its changes with the confidence and precision of the geologists, who suppose that they see the area of the operations they describe.

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* Besides the probability of the much wider extension of these formations over the chalk strata than was at first supposed, many discrepancies remain to be reconciled, and many of the mysteries of an ancient world resolved, before we can settle in the belief of this mode of formation. What aquatic animals will not live indifferently in salt or fresh water? When did the ocean become salt, and under what circumstances was mineral salt deposited, and at what æra? How far will the phenomena of lakes and estuaries in the present day go to explain a fresh-water formation upwards of two thousand feet in thickness, the area of which becomes covered with a long succession of generations of a single animal, whilst its hundred rivers must cease to pour the tides which they afterwards resume? These, and many other questions, must be answered before there can be any amendment of the observation of an eminent geologist, "that we really know very little about formation."

# ON OUTLIERS-BY-PROTRUSION.

In reviewing the outskirts of the District made the object of the "Survey" of the foregoing Essay, the writer's notice was drawn to a remarkable chalk-eminence upon the coast, between Worthing and Little-Hampton, called *High-Down*.

High-Down stands considerably in advance of the general line of chalk-hills, and is insulated by a breadth, between them, of two miles of plastic clay, covered by the woods of Patching, Clapham, and Castle-Goring. It has, therefore, the character of an Outlier; and upon a closer inspection, was found to present an escarpment to the sea, from which it is about two miles distant, and to have a northerly dip,—in opposition to the general inclination of the South Downs. The observation of this phenomenon immediately suggested the thought, that the well-known Outlier of *Ports-Down*, in Hampshire, would be found to be in the same predicament. And as there is nothing to be observed of High-Down, which will not apply to the larger outlier above-mentioned, a description of the latter will suffice.*

Ports-Down is a long narrow ridge of chalk, running east and west, which, rising three or four hundred feet above the level of the sea, overlooks the Island of Portsea, and the several islets and inlets of its celebrated harbour. To these, and to the south, it presents an abrupt escarpment; on the other side, it slopes rapidly northward, and is quickly lost, under the plastic clay and sands of the "Forest of Bere;" of which there is about five or six miles, between it and the main body of the chalk of the South Downs, with which it forms a trough or basin. In advance, and at more than double the distance, are the chalk-hills of the Isle of Wight. It therefore distinctly belongs to, and is an emanation from, the north side of the Hampshire basin.

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* The reader may take the Ordnance Survey, or any other good map which marks the high grounds, for a guide.

At the eastern extremity, the chalk rises out of the plastic clay at Bedhampton, and, taking a direct course westerly, gradually attains its greatest elevation between Cosham and Portchester; it then gradually declines, and, after a course of about seven miles, sinks again under the plastic clay, at Fareham. Here it ceases to be an outlier, but the line of elevation can be traced farther westward, and the chalk is sometimes quarried through the overlying strata, beyond Fareham, and comes to the surface again, at Titchfield and Funtley; beyond which, this research has not been carried.

At the eastern extremity of the ridge where it emerges, at Bedhampton, it dips gently northward, with a lateral bearing to the *east*. In the centre the inclination is much greater. There is no good section where it appears to be the greatest, but where the hill is intersected by the Portsmouth-road, it amounts to twenty-five or thirty degrees, and at the highest, is perhaps nearly forty. Westward from thence, it is again diminished, and in the chalk-pits near Fareham, is found not only to have lost all its northward dip, but also to have returned to the general southward declination of the Hampshire Downs, dipping five degrees in that direction, with a lateral bearing *westward.* In inclination, therefore, it traverses an arc of forty-five degrees, in the space of about four miles. To answer to this contortion, a course of fissures may be traced, and these are particularly well displayed in the chalk-pit, close to Fareham, where, as the outlier sinks under the plastic clay, they have not been exposed to obliteration by denuding causes. Through a gap begun by some of these fissures, or a larger disruption of the whole mass, the rivulet passes, which takes its course transversely to the chalk, into the Fareham inlet; for west of it, the general bearing of the ground, by Upland-House, and on towards Funtley, is indicative of a resumption of the northerly dip.

A moment's consideration will show, that such an outlier as this is very differently circumstanced from the more common one, or that which is entirely detached from the main body; separated by the removal of the intervening parts, and therefore properly the *outlier of erosion.* This, although it is an outlier in reference to the surrounding parts upon the surface, is still connected with, or incumbent upon, or in juxtaposition with, the kindred stratum below; and may therefore be called an *outlier-by-protrusion.*

The relations of the two specimens of Ports-Down and High-Down are exceedingly simple, and their history extremely well displayed. The opposing dip, contortion, and form of both eminences, are satisfactory proof of their protrusion from the parent stratum below;—whether effected by a separate and distinct propelling impulse, or simply *by arrest, by the interposition of some opposing substance, during the subsidence of the main body,* it is not now material to inquire. The mass thus detached and elevated, a part of which forms Ports-Down, must have been covered, as some portion of it still is, by the overlying strata, and is an outlier only where its highest parts have been exposed to the denuding forces.

No line of country exists, indicative of any connexion between Ports-Down and High-Down, which are twenty-four miles asunder.

It belongs to the general history of chalk-basins, and would pass the limits prescribed to this research, to endeavour to show which of the actions, above referred to, have produced these outliers. Either way, they tend powerfully to illustrate the theoretical parts of the foregoing Essay, and to prove the disruption and displacement of the chalk,—the act of basining,—posterior to the deposit of the higher strata.

The Isle of Thanet is probably an outlier of this description, and the writer is informed that Windsor stands upon chalk, which must therefore be also an outlier-by-protrusion, and perhaps so also the chalk islands in the Paris basin.

It will be easily seen, that it is not necessary that such outliers should have a dip and an inclination opposite to the main body. In the elevation of the former, or the subsidence of the latter, they may both preserve the same parallelism, or nearly similar relations to the horizontal line. It is enough, if it be proved, that they are out of the direct line with each other below; and that the detached portions have been exposed to the flood of denudation upon the surface, and are outliers where they have been elevated within the range of the denuding force.

THE END.

# NOTES.

1.—It has been suggested, that a more forcible exposition of the evidence of transverse fissures was yet to be derived, from a collective view of the elevation of all the strata concerned in the Weald-denudation, from the east westward, or in a direction coincident with their apparent longitudinal disposition. It has been stated (*p.* 59,) that a double elevation, or a force operating obliquely to the planes of the strata, was the cause of the cross-fracturings which opened the river-courses, and broke up the contents of the Weald Valley. It is convenient to use the terms longitudinal and transverse, but they, of course, are merely conventional;—that which is tranverse to the exposed part of a stratum, may be longitudinal, as to its whole extent. In the case of the weald,—the elevation is greatest north and south, or in the direction of the lesser diameter of the valley; hence the longitudinal disposition of the bassetting edges, from east to west;—whilst east and west, or in the direction of the greater diameter of the valley, it is comparatively trifling; and hence the narrowness of the river fissures. This may be judged of by the point of junction of the chalk with the glauconite, which is at the level of the sea at Beachy-Head, or on the Kentish coast, but may be computed to have risen two hundred feet above it, under the Alton-Hills. The river, and other transverse fissures, answer to this elevation, and the obliquity is shared by the several intervening masses, though it may be in very unequal proportion. In tracing the marks of this operation, it seems natural to look for an elevation of the western side of every material fissure; and it is not improbable that this is often, if not always, the case. At p. 70 it is said, that the Malm rises higher on the western side of the Arun, than on the eastern. The bottom of the remarkable bed of green-sand at Bury stands twenty feet at least above the river, whilst the corresponding part, with which it must once have been continuous, east of the river, at Amberly, is lost under its alluvium. Had the parts remained in juxta-position, this would have been only a *fault;* but, in conjunction with the lateral divergence, (*p.* 70,) it becomes a gaping and a river fissure.

Many circumstances, in evidence of the joint operations of basining and denudation, may have been overlooked in this Memoir, which is to be considered as an Introduction to, rather than as a full History of those Phenomena.

2.—It may be asked also, why there should be any balancing between the proofs of the elevation of the lateral, or the depression of the central parts, of what are called basins? It has already been stated, that in this stage of the inquiry, it is not material in which way these contortions have been effected: they may be the joint operation of both causes.

The elevation or depression of masses of various densities, and degrees of tenacity, must throw them into disorder, and alternate elevations and depressions must be the consequence. And it cannot be supposed but that *the basining of the chalk strata, and the concomitant phenomena, are links in a chain of greater operations, coeval or simultaneous with them.* Every considerable elevation of the solid parts of the globe implies a corresponding depression, positive or relative. If a new continent were to rise out of the Pacific Ocean, the position of the old continents would be changed;—positively, by as much as they might sink into the abyss formed by the elevation of the new; relatively, (if they did not suffer such an accident,) in the exact proportion of that elevation, of the quantity of water necessarily displaced, and the consequent change in the level of the sea.

3.—A note has been hazarded *(p.* 89,*)* upon the cause of the accident at the Thames Tunnel. That note was written in July last, and notwithstanding what has since occurred, the conjecture, that the misfortune arose from some original disturbance in and below the bed of the river, remains in full force. A simple "fault," which is a fissure with change of position, but without separation of the fractured parts, might give little or no impediment to the operation of tunnelling; but a gaping fissure, which has admitted diluvium, or drift of any sort, must always be doubtful ground.

Some rivers are bedded in their own alluvium, of an unknown depth; others are still wearing away the mineral strata in which their channels were first formed; others again, in different parts of their courses, are in both these predicaments.

4.—It may seem almost ludicrous to speak of the vallies and river-courses of the North and South Downs, in the language usually applied to mountain districts; but the passes of Leatherhead and Smitham-bottom (p. 61) have the same geological relations, in the eyes of the curious traveller, when they transmit him in his easy course to Brighton, as those of the Trosachs, or the Dargle, when they admit him to a view of the wild beauties of Katrine, or Killarney; or as any other gaps or transverse vallies, of the most mountainous countries.

# EXPLANATION OF THE PLATES.

**Map.**—The outcrop and bassetting edges of the several strata, will always be found within a short distance of the lines of colour; with the exception of the notches and indentations, which it would be difficult to follow upon so small a scale.

The *arrows* denote the anticlinal disposition of the strata, on the line of the longitudinal fissure of Greenhurst, Henfield, and Poynings. The same line of disturbance is carried on by lesser indications, towards Duncton-Hill; but the retroversion of the Shanklin-sands is plainly displayed as far west as Greatham.

Since the Memoir was sent to press, it has been discovered that the subsided or retroverted Galt-outliers bordering the Arun and Rother, at Hardham and Tripp-Hill, are connected with the main body by a narrow and thin isthmus; which, branching off from the New-Woods, runs through Cold-Waltham Park, and expands upon the north side of the ridge of ferruginous sand of Cold-Waltham Common, sloping northward, and losing itself under the diluvium and alluvium of the valley, in which the Rother takes its course to join the Arun at Stopham;—the trough or basin, described in the text, as extending from Warminghurst to Fittleworth, at the back of the great longitudinal fissure above mentioned. The Isthmus itself, of the connecting Galt, occupies a little valley of subsidence.

The principal alluvial deposit of the rivers is left uncoloured.

**Plate I.** *Fig.* 1.—The section from Bury-Hill to Billingshurst, on the line A.B. of the map, is nearly in the line of the Arundel and Bognor Road. The displaced galt at Hardham is omitted, to prevent misunderstanding as to the general disposition of the strata underlying the chalk. It will be found in the shorter section, *Plate* III. *Fig.* 2.

*Fig.* 2.—Some approximation to the relative thickness of the several strata in the perpendicular section, may be confidently relied upon; the previous estimate having been confirmed by the evidence of the wells, inserted since the section was made, as they have come to the writer's knowledge.

The crest of the escarpment of the South Downs, a small part only of the upper or flinty chalk, is included in this section.

The sandy courses of the Wealden are not exaggerated, but the limestone or marble courses are, for the sake of illustration.

Neither this section, nor the horizontal one, A.B., are carried into what may be considered the lowest courses, or central point of the "Forest Ridge." And nothing is more remarkable than the great thickness of the Wealden formation. Wells so far within it as Horsham and its neighbourhood, have penetrated beds of clay from one to two hundred feet, without water.

*Fig.* 3.—Is a section of Toat-Hill, a peninsulated mass of the uppermost clay of the Wealden.

*Fig.* 4.—Is a section of the retroverted Shanklin-sands of Henfield, as they are exhibited in the road from the village to Broadmere Common, towards Steyning.

*Fig.* 5.—Is Mr. Conybeare's section of the London Chalk-basin, and the excavation of the Weald; with the colours and nomenclature of this Memoir.

PLATE II.—The map of the Weald-denudation, or excavation, is taken from Mr. Grenough's map, and Mr. Mantell's illustrative map of the same kind.

The Diagrams will be understood by perusal of the theoretical parts of the Essay; and are referred to in pp. 65 and 72.

PLATE III.—The sections have reference to that part of the Theory of Derangement, which treats of the Vale of Greenhurst.

The Diagrams are meant to represent some of the forms in which the broken strata arrange themselves.

The "Outlier-by-protusion" may serve for a section of Ports-Down-Hill, and the adjacent country, from Portsmouth to Horndene.

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## SYNOPTICAL TABLE.

| FORMATIONS. | SUBDIVISIONS. | NATURAL CHARACTERS. | LOCALITIES. |
|---|---|---|---|
| A. CHALK. | 1 Upper Chalk.<br>2 Lower Chalk. | Soft, with Flint nodules.<br>Hard, without Flint. | South Downs. |
| B. GLAUCONITE. | 1 Malm. | Blue-chalk-marl above, graduating into indurated, argillaceous limestone, or Malm-Rock; with subordinate beds of *Green-sand*.<br>Containing Ammonites, Pectines, Inocerami, &c.<br>Soil, moist and fertile. | Sutton, Bury, Amberley, Washington, Steyning—the high grounds immediately under the Chalk-hills. |
| | 2 Galt. | Upper part,—harsh and shaley brown clay, mottled blueish;—<br>Lower beds,—blue and black shale, and stiff clay; sometimes containing ferruginous concrete;—and Marl, as at......................<br>Ammonites,—other fossils said to have been found in wells.<br>Soil, good for pasture ground, and for the growth of Oak and Elm. | Bottom of Sutton and Bury hollow-ways, Washington, Rowdell, Fulking, &c.<br>Bignor-Park, Bury Common, New-Woods, Hardham,<br>Wiggonholt.* |
| | *Ferruginous* | Coarse Red-sand, with layers of Ironstone, compact and cellular.<br>White, yellow, brown, and black sand, with Quartz grains, and occa- | Burton, Redhill near Bignor, Sandgate, Sullington, Pulborough, Fittleworth, Henfield. |

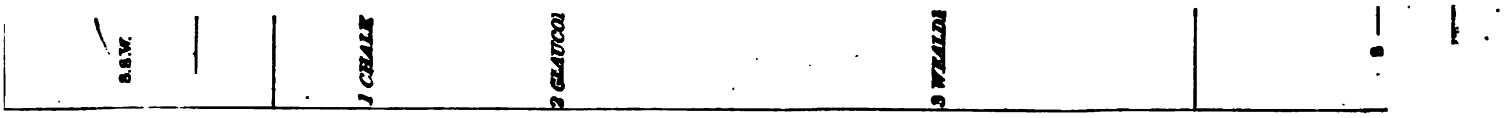

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Plate 1.

Fig. 1.

Section from Bury Hill to Billingshurst or line A.B. on the Map.

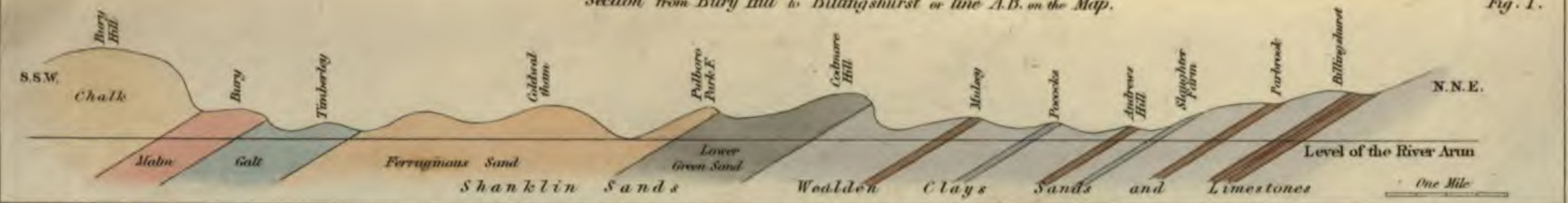


Fig. 2.

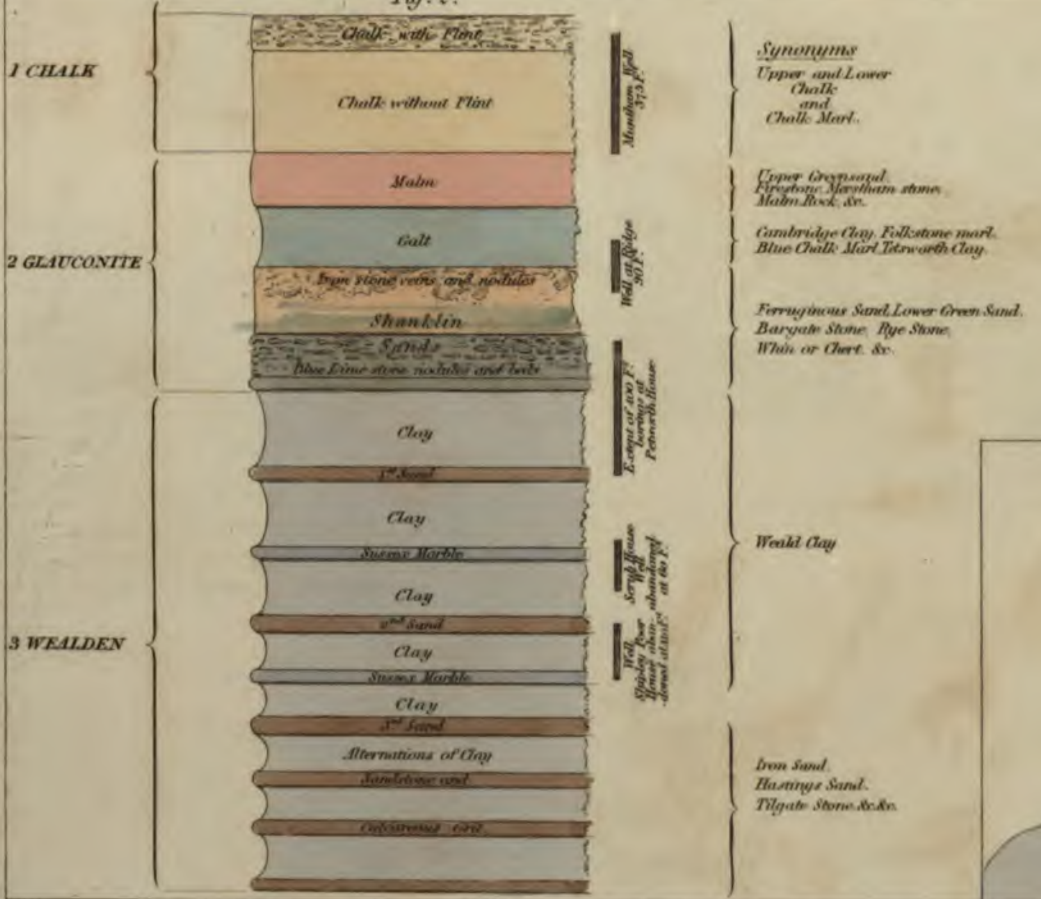
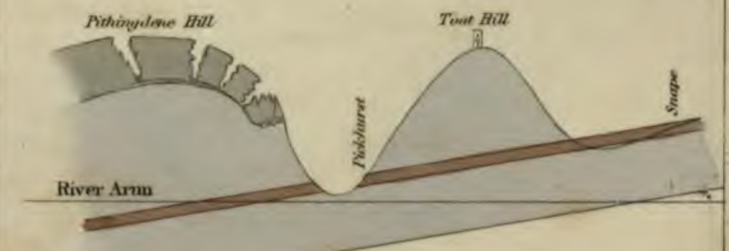

1 CHALK
2 GLAUCONITE
3 WEALDEN
Chalk with Flint
Chalk without Flint
Malm
Galt
Iron stone veins and nodules
Shanklin
Sands
Blue Lime stone nodules and beds
Clay
1st Sand
Clay
Sussex Marble
Clay
2nd Sand
Clay
Sussex Marble
Clay
3rd Sand
Alternations of Clay
Sandstone and
Calcareous Grit
Munham Well 375 F.
Well at Ridge 90 F.
Extent of 400 F. borings at Petworth House
Scragg House Well abandoned at 60 F.
Well Shipley Poor House aban-doned at 100 F.
Synonyms
Upper and Lower Chalk and Chalk Marl.
Upper Greensand. Firestone Merstham stone. Malm Rock &c.
Cambridge Clay. Folkstone marl. Blue Chalk Marl Tetsworth Clay.
Ferruginous Sand. Lower Green Sand. Bargate Stone. Rye Stone. Whin or Chert. &c.
Weald Clay
Iron Sand. Hastings Sand. Tilgate Stone &c &c.

Fig. 3.



Underley a longitudinal
Valley of Erosion N. of Pulboro'.

Fig. 4.

Henfield Hill
Dip. N. 5°

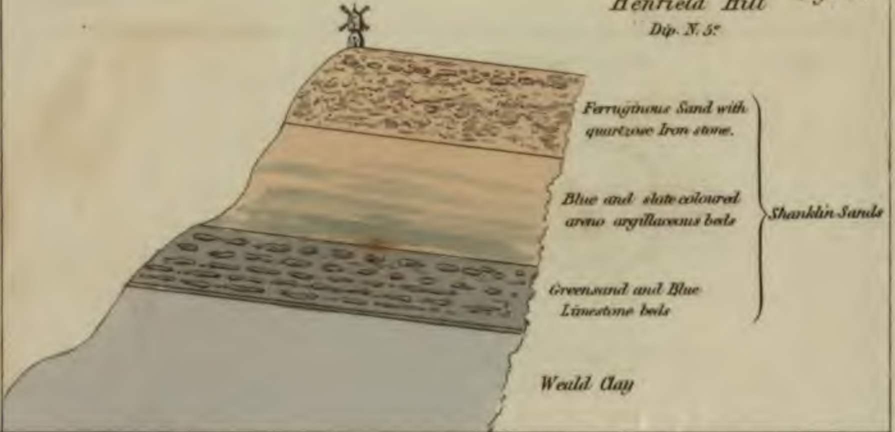
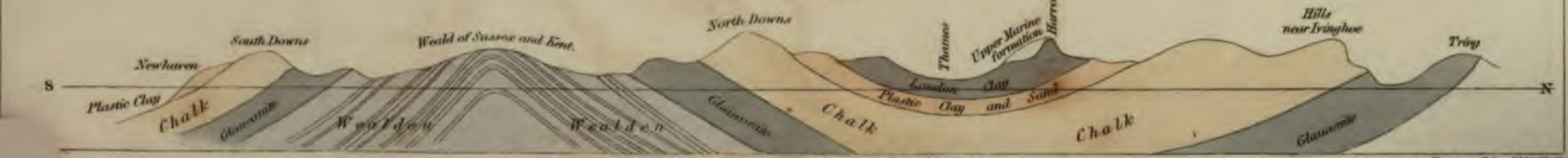

Ferruginous Sand with quartzose Iron stone.
Blue and slate coloured areno argillaceous beds
Greensand and Blue Limestone beds
Shanklin Sands
Weald Clay

Fig. 5.

Section from Newhaven in Sussex to Tring in Hertfordshire.
after the Revd W. Conybeare.



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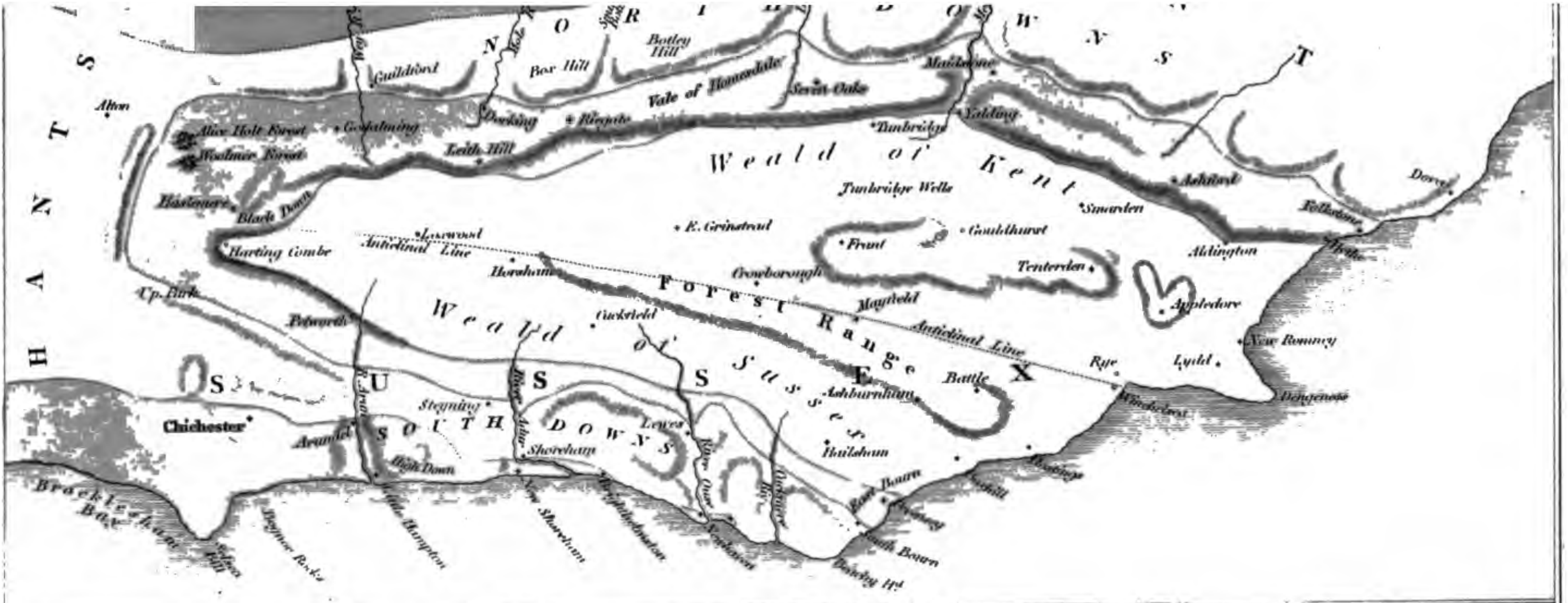


The manner in which transverse fissures unite to produce the effect of more direct longitudinal ones, and to become river channels.

Fig. 2.

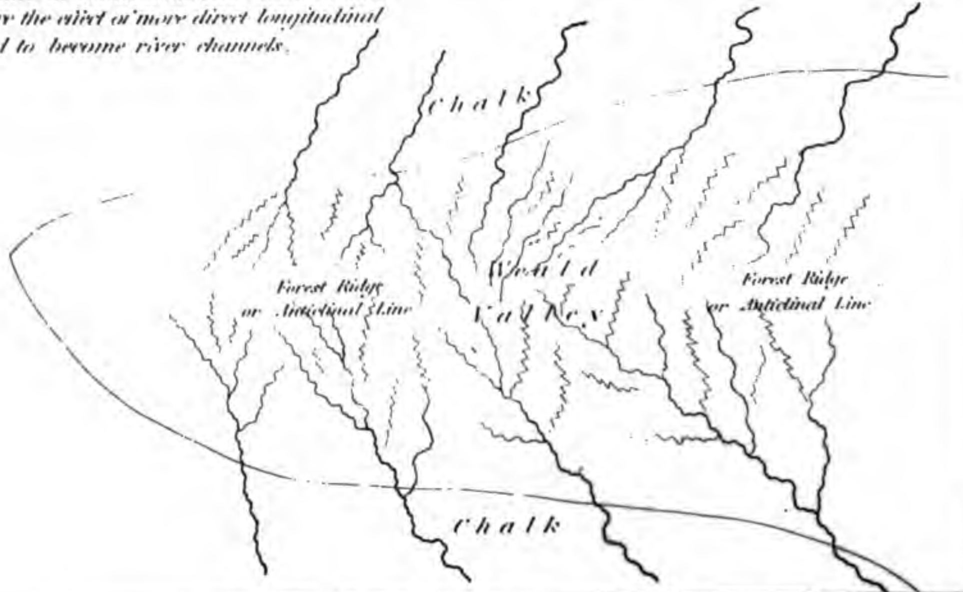
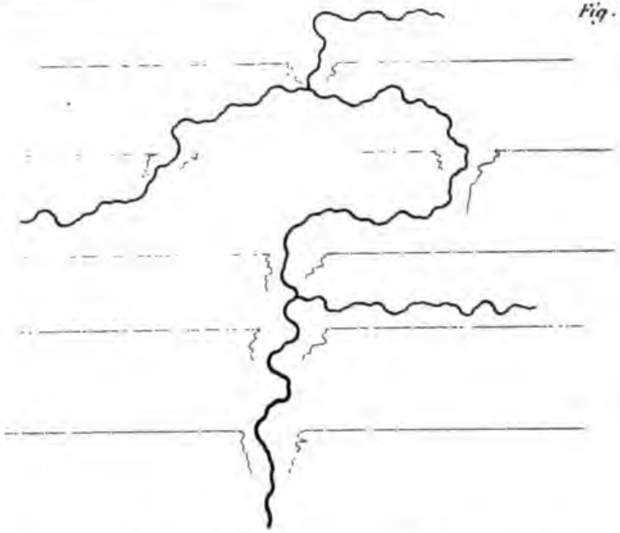

Chalk
Forest Ridge or Anticlinal Line
Weald Valley
Forest Ridge or Anticlinal Line
Chalk

Fig. 3.



River courses through transverse fissures in basseting edges.

Engraved by Sidʸ Hall.

Beds above the Chalk ▭ Chalk ▭ Glauconite ▬ Wealden ▭

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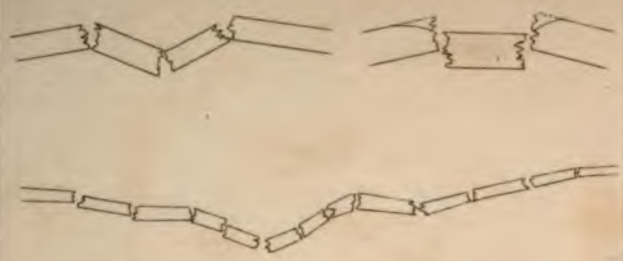
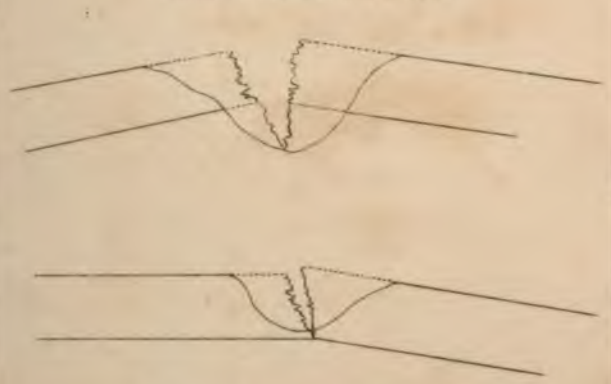
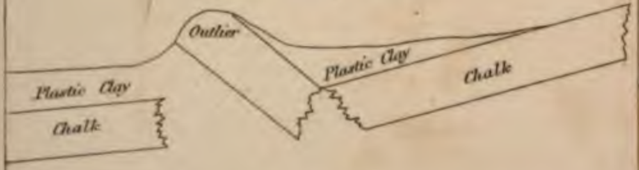
Vallies of Subsidence



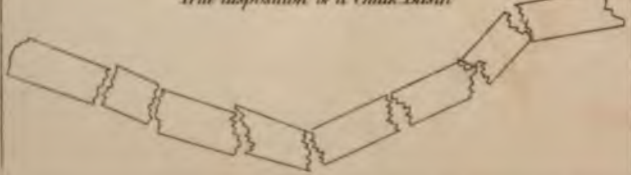
Vallies of Fracture and Erosion



Chalk Outlier by Protrusion



True disposition of a Chalk Basin



Section C.D.

Shewing the disruption of the Green sand and the exposure of the Weald Clay at Greenhurst. A Section from Edburton thro' Henfield to Chestham gives the same relative positions east of the R. Adur.

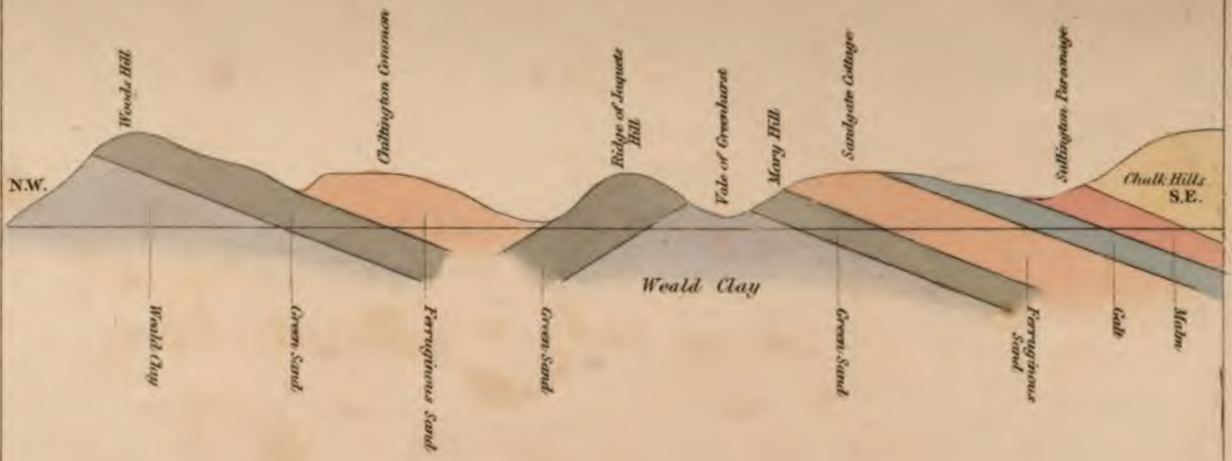
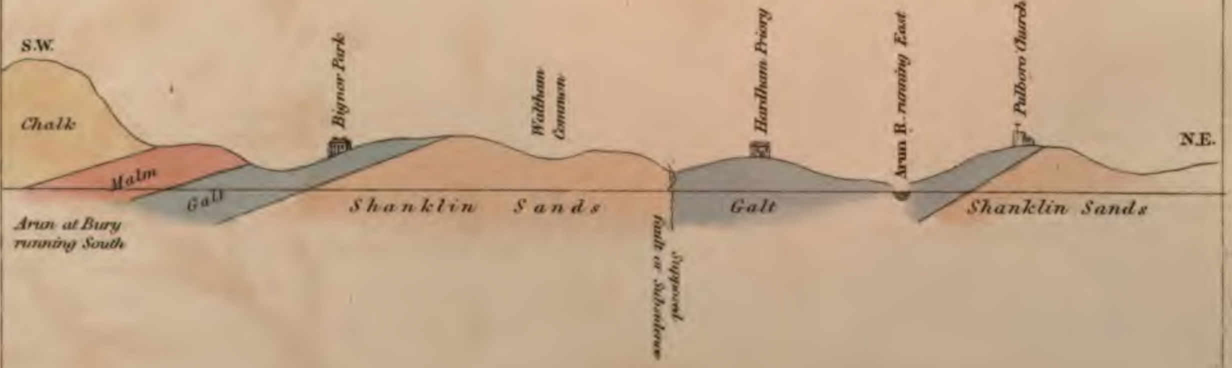


Fig. 2.

Outlying Galt, at Hardham and Pulborough.



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